HENRY B. H. BEAUFOY, F.R.S.

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GREAT BRITAIN, Board of Customs & Excise

23139

1745

PAPERS

PRESENTED TO THE HOUSE OF COMMONS,

RELATING TO

EXPERIMENTS

MADE

By Order of the COMMISSIONERS of EXCISE for *Scotland*,

TO ASCERTAIN THE RELATIVE QUALITIES

OF

MALT made from BARLEY and SCOTCH BIGG;

&c.

Ordered to be printed 6th *June* 1806.

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LETTER

From the Commiſſioners of Exciſe, *North Britain,* to the Right Honourable the Lords Commiſſioners of His Majesty's Treaſury;—dated 17th May 1806.

May it pleaſe Your Lordſhips,

1. Letter from the Commiſſioners of Exciſe, Scotland, to the Lords of the Treaſury.

WE now beg leave to acquaint your Lordſhips, That, in purſuance of the directions ſignified by Mr. Huſkiſſon's Letter of the 4th of Auguſt 1804, relative to our cauſing a ſeries of Experiments to be inſtituted for aſcertaining the proportional value of Malt made from Bigg to Malt made from Barley, we proceeded accordingly to take the neceſſary ſteps for carrying the intentions of your Lordſhips into full effect. We have at different times reported to your Lordſhips that theſe Experiments were carrying on; we have now to ſtate that they are completed, and a full Report upon the ſubject, containing a minute and accurate Statement of the reſult of all the various operations carried on, has been carefully drawn up by the very able and intelligent Gentlemen under whoſe ſuperintendence and direction the trials were conducted. This Report has only recently been put into our hands, the labour of arranging the different particulars, and conſtructing with accuracy the numerous Tables neceſſarily referred to, having occaſioned a longer delay than was at firſt expected. The Report, with the accompanying Tables, we now beg leave to tranſmit to your Lordſhips.

The Report appears to be ſo accurate and complete, in the Statement of all the particulars which can be of importance in affording the information wiſhed for by Parliament upon the ſubject of theſe Experiments, that it is altogether unneceſſary for us to make any farther obſervations in regard to them. But that your Lordſhips may have the whole buſineſs fully in view, we think it proper to ſtate ſhortly the preliminary ſteps that were taken by us for having all the requiſite preparations made ſo as to enſure, in the beſt manner poſſible, the fairneſs and accuracy of the trials that were thus to be inſtituted.

Immediately after the receipt of Mr. Huſkiſſon's Letter before-mentioned, we applied to Dr. Hope, Profeſſor of Chemiſtry, Dr. Coventry, Profeſſor of Agriculture in this Univerſity, and Dr. Thomſon, Lecturer in Chemiſtry, in this City, for their advice and aſſiſtance in carrying on and ſuperintending the different Experiments to be inſtituted. Theſe Gentlemen readily agreed to undertake the buſineſs, and, in conjunction with them, the ſeveral preliminary ſteps were from time to time adjuſted.

The firſt object of conſideration, was the Scale upon which the Experiments were to be conducted, and the manner of carrying them on. It occurred at once to the Gentlemen who were to ſuperintend the buſineſs, and in that idea we fully coincided, that no Experiments of the nature intended could be ſatisfactory, nor their reſult ſufficiently relied upon, if they were not conducted upon a ſcale nearly as extenſive as in ordinary manufactories. It farther appeared, that to render any Experiments thus carried on entitled to full confidence and attention, it would be of advantage that they ſhould occaſionally be repeated in different premiſes, ſo that if any accidental circumſtance ſhould affect the operations in one, it might be corrected by what took place in the others. And, laſtly, it was perfectly obvious, that no trials of the comparative value of the different

ſpecies

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ſpecies of grain could be complete, unleſs all the different kinds of each were ſubjected to ſimilar proceſſes, and actually employed, as they uſually are in practice, for the purpoſes both of Brewing and Diſtilling.

With theſe views we proceeded, firſt to procure three ſeparate Breweries ſituate in different parts of this City, and to have theſe properly fitted up, and furniſhed with a ſufficient apparatus for carrying on every operation that ſhould be deemed neceſſary or uſeful in the buſineſs. The places and utenſils were accordingly got ready under the inſpection of ſome of our moſt experienced practical Officers, as well as ſome ſkilful practical Brewers and Maltſters, and the whole fitted up to the ſatisfaction of the ſcientific Gentlemen mentioned above as ſuperintending the buſineſs.

The next and undoubtedly the moſt important object of attention was, the procuring a ſupply of grain of all the requiſite kinds, in ſuch a manner and with ſuch precaution that Parliament and your Lordſhips might rely with full confidence, on the quality and ſpecies of each particular parcel being preciſely as ſtated, without alteration or mixture, or ſubſtitution of one kind of grain for another. The methods adopted by us for this purpoſe, we beg leave ſhortly to ſtate :

The ſpecies of grain upon which, after full conſideration of the directions contained in Mr. Huſkiſſon's letter above referred to ; it appeared to us that the propoſed Experiments ſhould be made, ſo as to yield a fair reſult, were :

English Barley.
Scotch Barley.
Scotch Bear or Bigg.

Three different qualities of each, beſt, middling, and inferior, to be ſeparately provided, and each of theſe in a ſimilar manner ſubmitted for examination. For procuring this ſupply of grain, we determined to employ ſome of our own Officers, who we had acceſs to know were well acquainted with the nature of the reſpective ſpecies of grain, and fit for conducting the buſineſs of having it purchaſed and conveyed, as propoſed, in the moſt ſecure and ſatisfactory manner. The propriety of committing the principal charge of this part of the buſineſs to ſome of our own Officers, in whom we could fully confide, rather than to perſons who could not be ſubjected to the ſame degree of reſponſibility, will at firſt ſight be evident to your Lordſhips ; but theſe Officers were alſo authorized and required to take the aſſiſtance of profeſſional perſons, in any particular caſe where that ſhould appear to be neceſſary or proper.

I. ENGLISH BARLEY.

The charge of purchaſing this ſpecies of grain was given to Mr. John Grant, General Surveyor of Exciſe. The inſtructions given him as to this part of the buſineſs, were the following :

“ Mr. Grant is to repair to London by land, as ſoon as poſſible, upon this
“ buſineſs, and when arrived there, to loſe no time in proceeding to have
“ the purchaſes made.

“ In making theſe purchaſes, the Board direct that equal quantities of
“ the different kinds of Barley wanted as after-mentioned, be purchaſed from
“ three different eminent Corn Factors in London ; that when the Com-
“ miſſion is given to each of theſe, he ſhall have intimated to him the
“ purpoſes for which the Barley is required, and deſired to furniſh a fair
“ and proper ſpecimen of all the three kinds wanted, for which ſpecimens
“ he is to be reſponſible.

“ The three different kinds of Barley to be purchaſed are, the *beſt*, the
“ *middling*, and the *inferior*. None, however, muſt be got but what is fit
“ for the purpoſe of, and actually may be uſed in Malting, either for
“ Brewing or Diſtilling.

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Letter from the Commiſſioners of Exciſe, Scotland, to the Lords of the Treaſury.

“ The total quantity of grain wanted, as now ſettled by the Board, to be purchaſed in London, is 233$\frac{1}{3}$ bolls of each ſort, that is of the *beſt*, the *middling*, and the *inferior* kind, making in all 700 bolls of Barley, to be purchaſed in equal proportions from three different Corn Factors, none of whom is to have communicated to him the Commiſſion given to the other.

“ When the Barley is purchaſed, every ſeparate kind and parcel muſt be immediately bagged up, under the inſpection of Mr. Grant and the Seller, the bag ſealed, and then marked according to the kind and quality of the Barley, as firſt, ſecond, third, and the quantity and weight of the contents. The bags muſt be ſo ſealed, that Mr. Grant may be able to atteſt, upon oath, the identity of the grain when delivered at Leith.

“ After being bagged up as directed, the Barley muſt be forthwith ſhipped, care being taken that no change or abſtraction be made of any part of it. It muſt be ſo ſtowed, on ſhip board, as to prevent, if poſſible, any riſk of damage in the voyage.

“ Mr. Grant will freight a veſſel from London to convey the whole to Leith, in a ſafe and proper manner, and he will come down in the veſſel himſelf, ſo as to be preſent at the delivery at Leith, and putting it into the granary.”

In purſuance of theſe inſtructions, Mr. Grant went to London, and purchaſed the following quantities of Barley, all of which he ſaw completely put up and ſecured as directed, and, under his own inſpection, conveyed to Leith, from which the ſeveral parcels were immediately removed to and lodged in the granaries, in ſeparate compartments provided for the purpoſe:

	English Meaſure,			Scotch Bolls, Scotch Meaſure.
	Qrs.	Buſhs.		
Norfolk - - - -	178	4	equal to	238
Kent - - - - -	120	0		160
Eſſex - - - - -	120	0		160
Suffolk - - - -	120	0		160
	538	4		718

II. SCOTCH BARLEY.

Mr. James Anderſon, Examiner of Exciſe, was directed to take the charge of this branch of the buſineſs. His inſtructions as to the purchaſe and conveyance of the grain, were in great meaſure ſimilar to thoſe given to Mr. Grant. He was directed to proceed to the places in which the greateſt choice of this grain could be had; that ſpecimens of the three different kinds, beſt, middling, and inferior, ſhould be purchaſed from the moſt reputable Corn Merchants and Dealers, and that theſe ſhould, when purchaſed, be put up, ſecured, and conveyed to Edinburgh, under the ſame regulations as were mentioned above for the Engliſh Barley. All this to be done under Mr. Anderſon's own inſpection, and in the ſame manner, that they ſhould be brought to Edinburgh, either by land or water carriage, as found moſt practicable and ſecure.

Mr. Anderſon accordingly purchaſed the following quantities of Scotch Barley, which were all ſecurely put up, and the whole conveyed to Edinburgh, either under his immediate view, or that of the Officers on whoſe care and fidelity he could rely.

r.
Letter from the Commiſſioners of Exciſe, Scotland, to the Lords of the Treaſury.

	English Meaſure. Qrs.	Buſhels.		Scotch Meaſure. Bolls.	Firlots.
Berwick - - - -	74	2	equal to	99	0
Eaſt Lothian - -	74	2		99	0
Mid Lothian - -	74	2		99	0
Weſt Lothian - -	74	2		99	0
Fife - - - - -	74	2		99	0
Perth - - - - -	77	2		103	0
Angus - - - - -	76	7		102	2
	525	3		700	2

Upon the arrival of the grain at Edinburgh, it was lodged in the granary, in the ſame manner as was done with the Barley brought from England.

III. SCOTCH BEAR or BIGG.

More precaution appeared to be neceſſary in regard to this than either of the other ſpecies of grain, that the danger of mixture or ſubſtitution might be avoided, and no doubt left as to the fairneſs of the ſpecimens upon which the trials were to be made.

Mr. Alexander Campbell, General Superviſor, and Mr. James Craig, Superviſor of Exciſe, were appointed to take charge of this branch. Their inſtructions as to the execution of it, were to the following purport:

"Meſſrs. Campbell and Craig are to proceed, as ſoon as conveniently " may be, to the different places in Scotland, where Bear or Bigg can moſt " properly be had, in order to purchaſe for the Board the neceſſary quan- " tities. William Coſſar, of Auchterouſe, near Dundee, an experienced " Farmer, is to accompany and aſſiſt them in the buſineſs.

" The places where the Board are of opinion it will be proper to try to " have purchaſes made, are,

" Dumfries, or the Country in that quarter.

" Brechin, or the other parts in the County of Angus, or the neigh- " bourhood.

" Aberdeen, or the different places in that County, or in the neigh- " bourhood.

" This, however, is not meant to reſtrict them as to the places where " they ſhould go; only they are directed to inform themſelves, as fully as " poſſible, where the Bear or Bigg may beſt be had, and proceed to theſe " places to make the purchaſes.

" The different ſpecies of Bigg to be purchaſed are, the firſt, the ſecond, " and the inferior, or third ſort; all of them, however, muſt be ſuch " grain as can be and is uſed for Malt, whether for Brewing or Diſtil- " ling, and none but ſuch as may be ſo uſed is to be purchaſed.

" The total quantities wanted will be about 230 bolls of each of the " above three kinds, or nearly 700 bolls in all.

" It would be deſirable, that as equal proportions from each of the " diſtricts where Bigg is produced could be got, ſo as to make the whole " a juſt and fair average of that grain over Scotland.

" To enſure the quality of the Bigg being genuine and unmixed, the " Board direct, that Meſſrs. Campbell and Craig, along with Mr. Coſſar, " ſhall, where they properly can, attend themſelves, and ſee the grain " threſhed out from the ſtraw, unmixed, ſo that there may be no poſſibi- " lity of doubt as to the quality. If they cannot attend this themſelves, " they muſt give the charge of it to ſome of the Officers of Exciſe, in " whoſe fidelity and care they can fully confide, who are in like manner to ſee " that done, and be anſwerable that the quality is genuine and unmixed.

" So

Letter from the Commiſſioners of Exciſe, Scotland, to the Lords of the Treaſury.

“ So ſoon as the Bear or Bigg is purchaſed at any place, it muſt without delay be packed up in bags. Theſe bags muſt be bound up and ſealed, and marked by Meſſrs. Campbell, Craig, and Coſſar, and their ſeals put thereon, that the danger of alteration may be prevented. When thus bagged and ſealed, the grain muſt, as ſoon as poſſible, be forwarded by a ſecure conveyance by water, if it can properly be done, to Edinburgh. And to prevent riſk of alteration, Officers of Exciſe may be directed to accompany it in the removal, wherever Meſſrs. Campbell and Craig may find that neceſſary.

“ Meſſrs. Campbell and Craig muſt be careful that the whole of the Bear purchaſed by them, be of the preſent year’s Crop, and in a ſound and marketable ſtate.

“ If the neceſſary conveyance cannot be immediately had, and it is found impracticable or very inconvenient to ſtay at any place till the means of forwarding the grain are found, Meſſrs. Campbell and Craig may in that caſe lodge the bags, after being ſo bound and ſealed, with ſome Officer of Exciſe, in whoſe care and fidelity they can confide, who is to keep the ſame and be anſwerable for it, till a proper conveyance to Leith or Edinburgh can be had.”

Agreeably to theſe inſtructions Meſſrs. Campbell and Craig proceeded to the different places ſpecified, and others where they knew or were informed that fair ſpecimens of Bear or Bigg could be had, and purchaſed the following quantities, which were all ſecurely put up, and by different conveyances brought to Edinburgh, under the inſpection either of theſe Gentlemen themſelves or ſome of the Officers of Exciſe in whom they could fully confide, and lodged in the Granaries in ſeparate places for the purpoſe.

	English Meaſure.			Scotch Meaſure.		
	Buſhels.	Qrs.		Bolls.	Firlots.	Pecks.
Ayr - - - - -	25	6	equal to	34	1	2
Kirkcudbright -	68	5		91	1	1
Dumfries - -	58	2		77	2	3
Lanark - - - -	37	0		49	1	1
Perth - - - -	46	7		62	2	0
Angus - - - -	77	5		103	2	0
Mearns - - - -	50	2		67	0	0
Aberdeen - -	189	0		252	0	0
	553	3		737	2	3

By this mode of purchaſing, packing up, and conveying the different ſpecies of grain, we apprehend that Parliament and your Lordſhips may rely with confidence on the fairneſs of the Specimens that were made uſe of in theſe Experiments. No precaution was omitted by the Officers employed, to procure in every caſe grain of the preciſe ſpecies pointed out, in ſuch a manner as to obviate all danger of change or ſubſtitution. And we have every reaſon to believe that no miſtake or alteration in this reſpect, of the ſlighteſt importance, actually took place.

We have only to add in regard to this, that though at firſt the Officers employed were directed, as your Lordſhips will find by the inſtructions, to confine their purchaſes to grain of the crop 1804, we afterwards, on farther conſideration, took off that reſtriction, and allowed the purchaſes to be made of grain of any preceding crop alſo, ſhould that be found requiſite. In fact, however, the only grain to be had was that of crop 1804; if any of a preceding crop was introduced, it was too trifling to merit attention.

1. Letter from the Commiſſioners of Exciſe, Scotland, to the Lords of the Treaſury.

The Granaries in which the different ſpecies of grain were lodged at Edinburgh were fitted up with ſeparate diviſions, in which each particular kind was depoſited ſo as to prevent any one being blended or confounded with another. This ſeparation was moſt ſtrictly attended to during the whole progreſs of the Experiments, no part of any parcel being taken out for trial, without an accurate note being made from what diviſion it was drawn. In this mode the accuracy of the Experiments, in regard to the kinds of grain made uſe of, was, we apprehend, completely ſecured.

After theſe preliminary ſteps had been taken, the courſe of Experiments was begun. As already mentioned, Drs. Hope, Coventry, and Thomſon, had the direction and ſuperintendence of the various operations. We further directed Mr. Grant, General Surveyor, to take the immediate management of the buſineſs in ſo far as the revenue was concerned, and to attend the meetings of the ſuperintending Committee, to give every aſſiſtance in his power on theſe occaſions. Proper Officers were appointed to attend and ſurvey during the whole of the operations. Profeſſional men of known ability were engaged, for conducting the different proceſſes of Malting, Brewing, and Diſtilling.

This detail of our proceedings we thought it right to lay before your Lordſhips, for ſatisfying your Lordſhips and Parliament ; how far the Experiments, of which the reſults are ſtated in the Report herewith tranſmitted, can be relied on, ſo far as regards the different ſpecies of grain provided, and the manner in which the operations referred to were in general conducted and carried through.

We beg leave juſt to add, that Mr. Grant being at preſent in London by orders of your Lordſhips, will be ready to attend at any time that your Lordſhips or the Committee of Parliament may deſire his aſſiſtance ; and will then give every explanation and information that may be wiſhed upon the ſubject of the Report, or any of the particulars connected with it.

We have the honour to remain, with great reſpect,
My Lords,
Your Lordſhips moſt obedient
and moſt faithful humble ſervants,
J. Wharton.
Jo. Stuart.
Ja^{s} Stodart.
Rob^{t} Graham.

P. S. The Report is contained in a box addreſſed to their Lordſhips, ſent by the Mail Coach, being too large for Poſt.

Exciſe Office, Edinburgh,
17th May 1806.

Right Hon^{ble}
The Lords Commiſſioners of
His Majeſty's Treaſury.

REPORT of the Experiments made, by the Direction of the Honourable BOARD of EXCISE in *Scotland*, to aſcertain the relative Qualities of MALT made from BARLEY and *Scotch* BIGG.

2. Report of Experiments on Malt made from Barley and Scotch Bigg.

MALT, from which a conſiderable Revenue ariſes, is made from two ſpecies of grain, Barley and Bigg. The latter is deemed inferior in quality, and pays a lower Duty.

	s.	d.	
The Duty on Malt made in England——is -	4	4	per Buſhel.
on Malt of Barley in Scotland - -	3	8⅛	
on Malt of Scotch Bigg - - - -	3	0⅛	

The Inhabitants of thoſe Counties of Scotland in which Bigg is principally cultivated, being of opinion that this grain is ſo much inferior to Barley, that the Duty on Malt made from it ought to be conſiderably lower than at preſent, applied to Parliament for an adequate reduction.

The ſubject came under parliamentary diſcuſſion, and in June 1804 there was printed, by order of the Houſe, a "Report from the Committee on the "re-committed Report, reſpecting the Rate of Duty payable on Malt made "from Barley and Bigg of the growth of *Scotland*."

From this Report it appears, that the Committee were of opinion, "That "there ought to be a deduction from the Duties impoſed in 1802 and 1803, "in favour of the Scotch Bigg, to the amount of one-third thereof."

The Lords Commiſſioners of His Majeſty's Treaſury, before concurring in a recommendation to Parliament on the ſubject of the deduction, judged it expedient that further inquiries ſhould be made, principally with the view of aſcertaining how far they could rely upon the ſtatements and calculations contained in the Appendix to that Report, and directed the Honourable Commiſſioners of Exciſe in Scotland to cauſe ſuitable Experiments to be made.

The object of theſe is ſo diſtinctly expreſſed in the letter addreſſed to the Board, that we take the liberty to inſert it:

"Gentlemen,

"The Lords Commiſſioners of His Majeſty's Treaſury, having had under their conſideration a "Report from the Committee on the re-committed Report, "reſpecting the Rate of Duty payable on Malt made from Barley of the "growth of England, and from Barley and Bigg of the growth of Scotland," to the Houſe of Commons in the laſt ſeſſion of Parliament, and their Lordſhips judging it expedient to cauſe further inquiries to be made into the correctneſs of the ſtatement and calculations in the Appendix to the ſaid Report, as far as relates to the relative quality of Malt made from Barley and Bigg reſpectively, previous to any propoſal for altering of Duties now payable on the latter, being ſubmitted to the conſideration of Parliament; I am commanded by their Lordſhips, to tranſmit the ſaid Report, with the Appendixes annexed, to you, and to direct you to cauſe ſuch further ſeries of Experiments to be made, by the moſt competent perſons that can be ſelected for this purpoſe, and under your own immediate inſpection, as may be neceſſary to enable you to aſcertain diſtinctly, and report to my Lords, previous to the next meeting of Parliament, your opinion as to the preciſe proportion of which the quality of Malt made of Bigg is inferior to that made of Barley, as well for the purpoſe of Diſtillation, as for the purpoſes for which Malt made from theſe articles reſpectively may be uſed.

And, with a view to the more ſatisfactory attainment of this object, my Lords deſire that the ſaid Experiments may be made from Barley and Bigg of the firſt qualities, and alſo from Malt produced from theſe grains of ordinary and inferior

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

rior qualities, it being the intention of my Lords to recommend to Parliament to lower the Duties upon Scotch Bigg, in whatever proportion, upon the average reſult of the above Experiments, the Malt made from this grain ſhall appear inferior in quality to that made from Barley.

“ My Lords further deſire, that the ſaid Report may include a return of the number of quarters of Malt made from Scotch Bigg, upon which Duty has been paid in the laſt five years, diſtinguiſhing each year, and alſo to ſatisfy themſelves, by a reference to perſons converſant with this buſineſs, whether Bigg converted into Malt, can in any and every ſtage of the proceſs of malting, and alſo when the article is completely malted, be diſtinguiſhed by inſpection from Malt making or made from Barley.

“ Treaſury Chambers, “ I am, &c.
“ 4th Auguſt 1804. (Signed) “ *W. Huſkiſſon.*”

Having, at the requeſt of the Honourable Board of Exciſe, undertaken the inveſtigation ſuggeſted by the Lords Commiſſioners of the Treaſury, and brought it to a concluſion, we now beg leave to preſent to the Board our Report upon the ſubject.

The object of our Experiments, as pointed out by the preceding letter, was to aſcertain the relative values of the two ſpecies of grain when malted, in order to diſcover whether the Duty on Malt from Scotch Bigg ſhould be reduced below its preſent rate, and if ſo what the reduction ſhould be.

It became proper, in the firſt place, to conſider in what manner the relative value of Malt, of different deſcriptions, could be beſt determined.

Malt is not an article of direct conſumption; it is employed only to produce Beer or Ale and ardent Spirits.

Hence its value, at leaſt as an article of taxation, muſt be conſidered as proportional to the quantity of either of theſe which it is capable of yielding. We had therefore no choice left. The operations of the Brewery and Diſtillery, were thoſe to which it was neceſſary to have recourſe.

Unfortunately, theſe proceſſes are liable, from various cauſes, to conſiderable uncertainty. Neither Ale nor Spirits pre-exiſt in Malt, both are the produce of complicated operations, and curious inteſtine changes; and the quantity obtained is often as much a criterion of the ſkill and attention of the operator, as of the quality of the Malt. This circumſtance neceſſarily occaſions uncertainty in the reſult of ſuch inveſtigations.

The nature of Beer or Ale adds to the difficulty; for it poſſeſſes no ſingle property which can ſerve as a juſt meaſure of the value of Malt. The caſe, indeed, is different with ardent Spirits, in which the quantity of Alcohol, the ſubſtance produced, can always be diſcovered. But on the other hand, more complicated operations are here required, ſome of which are obſcure and of an uncertain nature.

In addition to theſe ſources of difficulty, it muſt be obſerved, that Malt is not always of the ſame quality, even though it may have been procured from the very ſame parcel of grain, but varies in its goodneſs according to the ſkill with which the proceſs of malting has been conducted. It cannot, therefore, be a ſteady ſtandard of compariſon.

Aware of theſe. and of many other difficulties which we had to encounter, we could only hope to arrive at ſatisfactory concluſions by varying the inveſtigation as much as poſſible, and by repeating each ſtep of it ſo frequently as to afford a general reſult, not ſenſibly affected by the anomalies of individual Experiments. Two diſtinct modes of inveſtigation preſented themſelves, in the proceſſes of the Brewhouſe and of the Diſtillery; and, for the reaſons juſt ſtated, it was thought adviſable to purſue both.

In brewing Ale, Malt is indiſpenſable; but when the object is to procure Spirits, either raw Grain or Malt may be employed. This circumſtance was laid hold of as a farther means of varying our mode of inveſtigation. In the Diſtillery Proceſs, accordingly, two diſtinct ſets of Experiments were inſtituted; in in the one, Malt only was employed; in the other, the greateſt part of the grain was unmalted. Indeed, by availing ourſelves of the uſe of raw grain, we hoped to avoid, in a great meaſure, one of the leading cauſes of uncertainty; namely, the variable relation which Malt bears to raw Grain. It is a general opinion at leaſt, that the Malt of different Barleys and Biggs, if made with equal attention, bear nearly the ſame proportion to each other in the quantity of ſpirits which they are capable of producing, as the raw Grain does. How far this opinion is well founded will appear hereafter.

That Experiments ſimilar to thoſe in which we have been engaged, may be entitled to confidence, they muſt be conducted upon a ſcale nearly as extenſive as in ordinary manufactories. It is needleſs to ſay that the Honourable Board, fully aware of this, provided Brewhouſes and a Diſtillery, and engaged perſons of ſkill, well qualified to manage the proceſſes according to the uſual manner. It is equally unneceſſary to ſtate to the Honourable Board, that we were furniſhed with a ſufficient ſtock of grain of different ſpecies and qualities; that we were ſupplied with all the requiſite inſtruments, and that we had the perſonal attendance of as many revenue officers as could be of ſervice. But we cannot omit this opportunity of acknowledging the able and ready aſſiſtance we derived from the Gentleman whom the Honourable Commiſſioners directed to attend our meetings, and on whom they devolved the immediate charge of procuring every thing requiſite for the inveſtigation.

As ſucceſs in Brewing and Diſtilling depends ſo much on the manner in which the operations are conducted, we truſt we ſhall meet the wiſhes of the Honourable Board in laying before them a detail (even though, at times, it may ſeem minute) of the mode of procedure which was followed. We the more willingly enter into the detail, as from it a judgment may be formed of the attention and accuracy with which, we hope, every thing has been conducted.

The Report is divided into Four Parts.

The Firſt gives a ſhort account of the Grain:

The Second deſcribes the Malting Proceſs, and its Reſults:

The Third comprehends the Experiments in the Brewery;

And the Fourth, thoſe in the Diſtillery.

I. THE RAW GRAIN.

Barley and Bigg are ſpecies of Corn in many points of their character nearly allied. Both, however, are too well known in Great Britain to require any particular deſcription. They form every where one of our principal crops, but are reſpectively adapted for different ſituations, owing to a diverſity in their habit, which is extremely convenient in agriculture. Bigg, viewed as a ſpecies (for of it, as well as Barley, there are numerous varieties) is the more hardy plant. It grows more rapidly, and in general ripens ten days earlier than Barley, though uſually ſown more than a week or ten days later.

Barley requires not only more heat, but a better ſoil and more care in its cultivation than Bigg. The latter is beſt adapted for cold and high-lying diſtricts, or expoſed open grounds, being much leſs apt to ſhed its ſeed. On theſe and other accounts, it thrives in ſituations where Barley could hardly be raiſed, at leaſt where it could not be cultivated with advantage. Bigg has been raiſed for time immemorial in Scotland, and though not perhaps indigenous, is yet perfectly ſuited to the climate; but it is ſcarcely ſixty years, ſince Barley was produced in Scotland in any conſiderable quantity.

Nothing is more eaſy than to diſtinguiſh Bigg from Barley while in the ſtraw or ear, but when both are thraſhed out, it is a much more difficult matter. In general, the colour of Bigg is darker than that of Barley; it is ſmaller in ſize, inferior in weight, its huſk is thicker and ſmoother, and the flour or meal which it yields is generally ſuppoſed of a coarſer quality. But theſe differences are liable to conſiderable variations, and, in ſome caſes, the two grains approach each other ſo nearly, that much practice is neceſſary to diſtinguiſh them from

each

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each other. Indeed, ſeveral ſamples of Bigg, while under Experiment, were repeatedly confounded with Barley by perſons of conſiderable experience.

In the Experiments to be detailed in this Report, Barley raiſed both in England and Scotland was uſed; but the whole of the Bigg was the growth of Scotland. The Experiments were required to be made upon the three different kinds of each grain, known in commerce by the names of *beſt*, *middling*, and *worſt* qualities; or *firſt*, *ſecond*, and *third* qualities. The whole was the growth of 1804.

The Engliſh Barley ſelected was the produce of the counties of Suffolk, Norfolk, Kent, and Eſſex. It was purchaſed in Mark Lane by a gentleman ſent on purpoſe, aſſiſted by three reſpectable Corn Factors, with every neceſſary precaution to procure the very beſt ſamples, brought down by ſea under the charge of the ſame gentleman, and lodged in proper Granaries in Edinburgh. If the average weight be leſs than is uſual with Engliſh Barley, this inferiority muſt be aſcribed to the unfavourable ſeaſon, and not to any want of care in ſelecting the beſt ſamples expoſed to ſale.*

The Scotch Barley was the produce of the counties of Haddington, Edinburgh, Berwick, Linlithgow, Fife, Perth, and Angus. As the ſeaſon was uncommonly fine in Scotland, and the crop excellent, we may conſider it as affording a good ſpecimen of the beſt Scotch Barley.

The Bigg was from the counties of Dumfries, Kirkcudbright, Ayr, Lanark, Perth, Angus, Mearns, and Aberdeen. To prevent miſtakes, it was purchaſed in the ſtraw, thraſhed out, and brought to Edinburgh with the proper precautions. It affords the moſt favourable ſample of Scotch Bigg, as the crop of this grain in 1804 was in every reſpect excellent.

As it is no uncommon thing in ſome parts of Scotland, to ſow a mixture of Barley and Bigg under the name of *blended Bear*, it became neceſſary to aſcertain whether any of the ſpecimens ſelected for Experiment were of that kind. For this purpoſe, a portion of each parcel was ſown in the month of May 1805, and carefully examined in Auguſt while in the ear. The Engliſh Barleys, as might have been expected, were all pure, and we had the ſatisfaction to find, that none of the Scotch Barleys contained any mixture excepting two; namely, the ſecond and third qualities of Barley from the county of Perth, which contained a very trifling proportion, not amounting to an eighth of the whole. The Biggs were all equally free from any mixture of Barley except two; namely, the ſecond Dumfriesſhire and the third Kirkcudbright. The firſt of theſe might contain about a ſixth, and the laſt about a third of Barley. But theſe proportions are not ſtated as exact, being eſtimated merely by the eye as the grain grew in the field; and beſides, no allowance was made for the accidental mixture produced by the unequal ſcattering in ſowing the two ſpecies, on immediately adjoining patches.

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* It is well known that, in England, the Barley crop of 1804 was conſiderably under the average, while, in Scotland, it was one of the beſt ever known. This is ſuppoſed to have been occaſioned by a fortnight of very cold weather during the flowering of the Engliſh Barley. The Scotch Barley eſcaped this fate, becauſe it was in flower later, and not till the weather had become favourable. Beſides this advantage, the weather, at the period immediately previous to maturation, after ſome favourable ſhowers, became ſteadily dry and warm, which powerfully contributed to "fill" the grain, and render it plump and heavy.

Weight of the Grain uſed.

The following Table exhibits the weight of a Wincheſter buſhel and Linlithgow boll, of all the different parcels of grain procured for the purpoſe of Experiment.

TABLE I.—WEIGHT OF GRAIN.

ENGLISH GRAIN: *Firſt Qualities.*	Weight in Pounds Avoirdupois.		ENGLISH GRAIN: *Second Qualities.*	Weight in Pounds Avoirdupois.		ENGLISH GRAIN: *Third Qualities.*	Weight in Pounds. Avoirdupois.	
	pʳ Buſhel.	pʳ Boll.		pʳ Buſhel.	pʳ Boll.		pʳ Buſhel.	pʳ Boll.
Suffolk - - -	50.683	304.098	Norfolk - - -	50.570	303.420	Norfolk - - -	51.937	311.622
Norfolk - - -	50.375	302.250	Kent - - - -	50.062	300,372	Eſſex - - - -	48.414	290.484
Kent - - - -	49.877	299.262	Suffolk - - -	49.250	295.500	Eſſex - - - -	47.683	286.098
Average - -	50.311	301.866	Average - -	49.960	299.760	Average - -	49.344	296.064
SCOTCH GRAIN.			SCOTCH GRAIN.			SCOTCH GRAIN.		
Haddington - -	52.190	313.140	Haddington - -	52.265	313.590	Fife - - - -	49.754	298.524
Edinburgh - -	52.164	312.984	Berwick - - -	50.586	303.516	Edinburgh - -	49.601	297.606
Berwick - - -	52.062	312.372	Edinburgh - -	50.031	300.186	Haddington - -	48.987	293.922
Linlithgow - -	51.062	306.372	Linlithgow - -	50.950	305.760	Berwick - - -	48.855	293.130
Fife - - - -	51.539	309.234	Fife - - - -	48.703	292.218	Perth - - - -	47.836	287.016
Perth - - - -	50.226	301.356	Perth - - - -	48.193	289.158	Angus - - - -	46.965	281.790
Angus - - - -	49.312	295.872	Angus - - - -	47.179	283.074	Linlithgow - -	46.375	278.250
Average - -	51.222	307.332	Average - -	49.701	298.206	Average - -	48.339	290.034
BIGGS.			BIGGS.			BIGGS.		
Aberdeen - - -	48.741	292.446	Ayr - - - -	47.953	287.418	Ayr - - - -	47.290	283.740
Lanark - - -	48.560	291.360	Mearns - - -	47.914	287.484	Aberdeen - - -	46.560	279.360
Perth - - - -	48.586	291.516	Dumfries - - -	47.500	285.000	Kirkcudbright -	44.722	268.332
Dumfries - - -	47,500	285.000	Angus - - - -	47.200	283.200			
			Kirkcudbright -	47.031	282.186			
Average - -	48.347	290.282	Average - -	47.519	285.114	Average - -	46,191	277.146

This Table was conſtructed by weighing each parcel of Grain at the time when it was to be uſed. The quantity deſtined for each Experiment, was carefully meaſured out by a perſon accuſtomed to the buſineſs. Three Wincheſter buſhels were immediately weighed in the malting proceſſes; and the weight aſſigned in the Table is the average of theſe three. When the grain was uſed for diſtillation, the whole of it was weighed, and the weight of a buſhel found, by dividing the whole weight by the number of buſhels. The weight of a Linlithgow boll was taken as equal to that of ſix buſhels. The preceding Table is liable to error from two ſources.

The firſt is the difficulty of filling a buſhel equally. The ſhape of that meaſure is not favourable to preciſion; and, independently of that diſadvantage, the floor, on which the meting is performed, is known to make ſome difference, notwithſtanding every precaution and dexterity in the meaſurer. This error can only be rendered inſignificant, by taking the average from a ſufficient number of buſhels. Three, the number choſen in the caſe of malting, may perhaps appear too few; but, we truſt, from the attention paid to all circumſtances, that the weights aſſigned, come as near the truth as is neceſſary for

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practical purpoſes. In at leaſt ſixty different inſtances, forty buſhels of grain for diſtillation were weighed by *four* buſhels at a time. Now, upon comparing the weight of a buſhel found in theſe caſes, by ſtriking the average of the whole 40. with that which would have reſulted from being ſatisfied with any four buſhels, it appears, that the average error, in the laſt caſe, would not have exceeded $\frac{1}{200}$th; and that the greateſt error was never more than $\frac{1}{50}$th, except where ſufficient reaſons could be aſſigned for a greater difference from the mixture of grain of unequal weights. We think, therefore, that the average error, reſulting from inaccuracy of meaſurement, can ſcarcely be ſtated ſo high as one per cent.

The ſecond cauſe of error is not ſo eaſily appreciated. It is well known that new Grain, when put into a dry granary, generally loſes ſome weight, in conſequence of the exhalation of moiſture. This diminution of weight is accompanied by a ſtill greater diminution of bulk. Hence it happens, that a buſhel of old Grain generally weighs more than a buſhel of the ſame Grain when new. Now, as the different kinds of Grain contained in the preceding Table were not weighed all at one time, but in ſucceſſion, when they were to be uſed, it may be ſuppoſed, that the ſame relation will not exiſt between the weights of each, as if they had been all weighed at one and the ſame time.

It was impoſſible to guard againſt this ſource of error, without falling into others that would have been much more formidable. The quantity of Grain uſed was too great to be meaſured by one man in any reaſonable time; and had we employed different perſons, the error in meaſurement muſt have greatly exceeded any alteration of weight by the progreſs of the ſeaſon. But ſuppoſing that the whole Grain had been meaſured on the ſame day, the evil would not have been remedied; for, as the period of reaping, the various parcels differed according to the county, climate, or ſituation in which they grew, and was, beſides, unknown to thoſe who conducted the Experiment, it is obvious that, even in that caſe, all of them would not have been weighed at the ſame diſtance of time from that period. But there is reaſon to believe, that, when Barley or Bigg is fully ripe before it is cut down, and has been left a ſufficient time on the field, the Grain which it yields neither loſes nor gains much in weight, though kept for as long a time as any of that ſubjected to Experiment was kept.

The following Table, in which the very ſame parcels of Barley and Bigg were weighed at different times, will give us ſome idea of what the amount of the change of weight, by the progreſs of the ſeaſon, may be reckoned, in the caſe of the Grain uſed in the Experiments. The firſt column contains the names of the Grain weighed; the ſecond, the date of the two different weighings of each; the third, the weight per buſhel; and the laſt, the ratio of the weights, ſuppoſing the firſt weight to have been 100.

TABLE.—II.

GRAIN.	Dates of Weighing.	Weight per Buſhel.	Ratio of Ditto.
Norfolk - - - - - - 1	1805 January - - 24	50.375	100.00
	Auguſt - - 3	50.750	100.74
Kent - - - - - - - 1	March - - 28	49.75	100.00
	Auguſt - - 1	50.67	101.84
Suffolk - - - - - - 1	April - - 24	50.69	100.00
	July - - - 29	50.83	100.28
Kent - - - - - - - 2	March - - 26	49.984	100.00
	Auguſt - - 24	50.150	100 33
Suffolk - - - - - - 2	May - - - 6	48.845	100.00
	Auguſt - - 21	49.250	100.82
Edinburgh - - - - - 1	March - - 23	52.167	100.00
	July - - - 26	51.670	99.05
Lanark Bigg - - - -	January - - 24	48.562	100.00
	Auguſt - - 12	48.960	100.82

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From this Table it appears, that, even after an interval of ſix months, the increaſe of weight hardly ever amounted to $\frac{1}{100}$th part. Lying within the limits of error from meaſuring, this variation might be aſcribed to that circumſtance, were it not that the Grain longeſt kept, almoſt uniformly weighs moſt. But, we truſt, it muſt appear, that the difference is too ſmall to occaſion any material error. In ſome of the following Tables indeed, Grain will appear under the ſame name, in which the difference of weight is more conſiderable: but this circumſtance proceeds from two cauſes, which it will be proper to mention.

As the quantity of Grain of the ſame denomination brought from each county was conſiderable, it muſt be obvious, that the whole of it did not grow in the ſame field. On the contrary, ſmall parcels from various parts of the ſame county were preferred, as being likely to yield a better average. But they differed ſomewhat from each other in their weight. The Table marked No. 1, contains the average of the county, while the ſucceeding give the weights of the parcels uſed for the particular Experiments. Hence, theſe weights of the Grain cannot agree exactly either with each other, or with thoſe in the former Table.

Some variation in the weight of the ſame Grain, at different times, was likewiſe occaſioned by the neceſſity of cleaning the whole for the Diſtillation Experiments, by paſſing each parcel through the *fanners*. When the Grain was about to be malted, the light Grains were always ſkimmed off, and ſubtracted from the weight of the ſteeped corn, under the name of *ſwimmings*, which treatment brought each parcel nearly to the ſame degree of cleanneſs. Though this operation of ſwimming and ſkimming off the light ſeeds, could not be practiſed upon the raw Grain uſed for diſtillation; yet, as ſome parcels were obviouſly better cleaned than others, it was thought requiſite to bring them to equality in this reſpect by winnowing. This preparation, which of neceſſity made the laſt weighed parcels of the ſame Grain appear heavier than the firſt, had ſome influence in the differences which occur in the preceding Table (No. 2.) When allowance is made for it, the increaſe of weight, which the Barley ſuſtained by keeping, will be ſtill leſs than it appears from that Table. It may therefore, we think, in the preſent caſe be neglected altogether, without materially affecting the reſults.

The following Table exhibits the average weights of the Engliſh and the Scotch Barley and of the Bigg, obtained in the uſual way from the preceding Table (No. 1.)

TABLE III.—AVERAGE WEIGHT of the GRAIN.

GRAIN.	Weight per Buſhel, in Pounds Avoirdupois.	Weight per Boll, in Pounds Avoirdupois.	Weight per Boll, in Stones Scotch Troy.
1ſt Engliſh - - - - -	50.311	301.866	17.345
2d Engliſh - - - - -	49.960	299.760	17.224
3d Engliſh - - - - -	49.344	296.064	17.012
Average - - - -	49.872	299.230	17.193
1ſt Scotch - - - - -	51.222	307.332	17.660
2d Scotch - - - - -	49.701	298.206	17.135
3d Scotch - - - - -	48.339	290.034	16.665
Average - - - - -	49.754	298.517	17.153
1ſt Bigg - - - - - -	48.347	290.082	16.669
2d Bigg - - - - - -	47.519	285.114	16.383
3d Bigg - - - - - -	46.191	277.146	15,926
Average - - - - -	47.352	284.114	16.326

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From the Table it appears, that, though the firſt Scotch Barley was the heavieſt, yet the average of the whole Engliſh is greater than that of the whole Scotch, indicating a greater inferiority of the ſecond and third qualities of the latter than of the former Grain. If we ſtate the average weight of the Bigg at 1,000, then the weight of the different Grains tried, will be as follows, viz.

Weight

TABLE IV.—RAW GRAIN.

GRAIN.	Weight in Pounds Avoirdupois.		Specific Gravity.	SIZE.		SHAPE.		
	Per Buſhel.	Per Boll.		Average Weight of a Corn in Grains Troy.	Average Bulk of a Corn in Cubic Inches.	Average Length in Inches.	Average Breadth in Inches.	Average Thickneſs in Inches.
ENGLISH.								
1ſt Norfolk	50.375	302.250	1.290	0.681	0.00210	0.346	0.145	0.112
1ſt Kent	49.877	299.262	1.250	0.662	0.00209	0.343	0.142	0.108
1ſt Suffolk	50.683	304.098	- -	0.639	- - -	0.347	0.150	- -
2d Norfolk	50.570	303.420	1.272	0.665	0.00216	0.344	0.145	0.110
2d Kent	50.062	300.372	1.290	0.637	- - -	- -	0.143	0.112
2d Suffolk	49.250	295.500	1.307	0.601	- - -	- -	0.140	0.108
3d Norfolk	51.937	311.622	1.290	0.648	0.00198	0.345	0.141	0.107
3d Eſſex	47.683	286.098	1.291	0.593	- - -	0.333	0.139	0.103
Average	50.054	300.327	1.284	0.640	0.00208	0.343	0.143	0.108
SCOTCH.								
1ſt Haddington	52.190	313.140	1.333	0.7120	0.00211	0.336	0.154	0.120
1ſt Edinburgh	52.164	312.984	1.290	0.7056	0.00217	0.335	0.149	0.116
1ſt Berwick	52.062	312.372	1.307	0.6571	- - -	- -	0.143	0.111
1ſt Linlithgow	51.062	306.372	1.324	0.7650	0.00228	0.373	0.150	0.117
2d Haddington	52.265	313.590	1.333	0.6900	0.00204	0.346	0.145	0.111
3d Haddington	48.987	293.922	1.250	0.6570	0.00208	0.341	0.144	0.108
3d Linlithgow	46.375	278.250	1.333	0.7000	- - -	0.347	0.139	0.106
Average	50.729	304.375	1.310	0.6981	0.00213	0.346	0.146	0.112
BIGGS.								
1ſt Lanark	48.560	291.360	1.250	0.541	0.00710	0.328	0.133	0.103
1ſt Perth	48.586	291.516	1.227	0.586	0.00189	0.324	0.136	0.105
1ſt Dumfries	47.500	285.000	1.246	0.560	0.00177	0.322	0.136	0.108
2d Kirkcudbright	47.031	282.186	1.265	0.558	0.00174	0.324	0.139	0.106
Average	47.919	287.515	1.247	0.561	0.00177	0.324	0.136	0.105

For the explanation of this Table, a few remarks may be deemed neceſſary. 1. The ſecond column exhibits the *ſpecific gravity* of each kind of Grain. This was found by taking a given weight of Barley, 50 grains for example, and putting it into a weighing-bottle previouſly filled with water, and exactly balanced in a pair of ſcales. The bottle, weighed again, gave the weight of the water diſplaced by the Barley. The original weight of the Barley, divided by the weight of the water which it diſplaced, obviouſly gives the ſpecific gravity. Little dependence, however, can be put on the preciſion of this column, on account

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Weight of Bigg - - - - 1000.0
Scotch Barley - - 1050.7
Engliſh Barley - - 1053.2

Hence it appears, that the Barley was about 5 per cent. heavier than the Bigg.

As Grain may be ſuppoſed to differ in other particulars beſides weight, we have thought it worth while to inſert the following Table, which gives a view of ſuch other qualities as can be exhibited numerically.

TABLE IV.—RAW GRAIN.

EQUALITY OF SIZE.												Weight of Huſk.	GRAIN.
Weight of a Corn.			Length.			Breadth.			Thickneſs.				
Greateſt.	Leaſt.	Difference.	Greateſt.	Leaſt.	Difference.	Greateſt.	Leaſt.	Difference.	Greateſt.	Leaſt.	Difference.		ENGLISH.
0.6954	0.6647	0.0307	0.387	0.318	0.069	0.166	0.128	0.038	0.125	0.092	0.033	0.110	1ſt Norfolk.
0.6775	0.6410	0.0365	0.369	0.287	0.086	0.160	0.116	0.044	0.125	0.087	0.038	- -	1ſt Kent.
- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	1ſt Suffolk.
0.6960	0.6940	0.0470	0.384	0.300	0.084	0.159	0.126	0.033	0.120	0.096	0.024	- -	2d Norfolk.
- -	- -	- -	- -	- -	- -	0.169	0.119	0.050	0.132	0.102	0.030	- -	2d Kent.
- -	- -	- -	0.353	0.301	0.052	0.154	0.132	0.022	0.116	0.100	0.016	- -	2d Suffolk.
0.6740	0.6250	0.0590	0.362	0.328	0.034	0.159	0.118	0.041	0.121	0.083	0.038	- -	3d Norfolk.
0.6020	0.5830	0.0190	0.369	0.292	0.077	0.155	0.111	0.044	0.125	0.089	0.036	- -	3d Eſſex.
0.6689	0.6415	0.0384	0.370	0.304	0.067	0.160	0.121	0.038	0.123	0.092	0.030	0.110	Average.
													SCOTCH.
0.7342	0.6954	0.0388	0.368	0.286	0.082	0.171	0.107	0.064	0.131	0.089	0.042	0.123	1ſt Haddington.
0.7204	0.6906	0.0298	0.369	0.300	0.069	0.162	0.129	0.033	0.127	0.101	0.026	- -	1ſt Edinburgh.
- -	- -	- -	0.361	0.290	0.071	0.160	0.124	0.036	0.126	0.087	0.035	- -	1ſt Berwick.
- -	- -	- -	0.426	0.328	0.098	0.164	0.130	0.034	0.130	0.094	0.036	- -	1ſt Linlithgow.
0.7020	0.6700	0.0320	0.380	0.288	0.092	0.170	0.111	0.059	0.132	0.072	0.060	- -	2d Haddington.
0.6790	0.6260	0.0530	0.370	0.308	0.062	0.159	0.117	0.042	0.121	0.085	0.036	- -	3d Haddington.
- -	- -	- -	-	- -	- -	0.164	0.120	0.044	0.130	0.089	0.041	- -	3d Linlithgow.
0.7089	0.6705	0.0384	0.379	0.300	0.079	0.164	0.119	0.044	0.128	0.088	0.039	0.123	Average.
													BIGGS.
0.5508	0.5341	0.0167	0.378	0.278	0.100	0.152	0.116	0.036	0.118	0.087	0.031	0.125	1ſt Lanark.
0.6142	0.5668	0.0478	0.379	0.274	0.105	0.167	0.108	0.059	0.130	0.086	0.044	- -	1ſt Perth.
0.5875	0.5268	0.0607	0.370	0.267	0.103	0.160	0.114	0.046	0.122	0.088	0.034	- -	1ſt Dumfries.
0.5720	0.5520	0.0200	0.356	0.280	0.076	0.155	0.110	0.045	0.119	0.087	0.032	- -	2d Kirkcudbright.
0.5811	0.5449	0.0363	0.370	0.274	0.096	0.158	0.112	0.046	0.122	0.087	0.035	0.125	Average.

account of the difficulty that occurred in ſeparating the air-bubbles from the Barley-corns. The method that was found to anſwer beſt, was to weigh out the Barley, plunge it for a few moments into boiling water, then to pour cold water upon it, and introduce it immediately into the weighing-bottle; but even with every care, it was not poſſible to avoid all anomalies. For this reaſon it was not thought worth while to inſert the ſpecific gravity of every parcel of Grain ſubjected to Experiment.

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2. Next to the weight of the Grain, the moſt important point ſeems to be the *ſize* of the Barley-corns. Two compartments of the preceding Table are devoted to this particular. The firſt of theſe, under the title *ſize*, comprehends two columns, one of which gives the average weight of a ſingle Barley-corn in grains troy, and the other its bulk in parts of a cubic inch.

To obtain the firſt column, 5,000, and ſometimes 3,000 grains of troy of each kind of Barley were weighed out, and the number of Corns in each was carefully counted; all the very few accidental ſeeds of Oats, Wheat, Peaſe, &c. in the mixture being picked out, and weighed againſt ſuch a number of Barley-corns as were requiſite to make up the weight of ſuch extraneous ſeeds, which number was added to the ſum total. The whole weight, divided by the number of Corns, obviouſly gives the weight of a ſingle Corn.

The ſecond column, or the bulk of a Corn, was eaſily conſtructed from the weight and ſpecific gravity. Let the weight of a cubic inch of water be a, its ſpecific gravity 1, the ſpecific gravity of the Barley b, and the weight of a cubic inch of it x; then we have $1 : b :: a : x$, & $x = ab$. But ab is equivalent to a certain number of Barley-corns, the reciprocal of which number is obviouſly the bulk of a ſingle Barley-corn in parts of a cubic inch. As this column depends entirely upon the ſpecific gravity of the Barley, which, for the reaſons already aſſigned, cannot be very accurately aſcertained, no great dependance is to be put upon it; but it may be conſidered as an approximation to truth.

3. The *ſhape* of a Barley-corn approaches that of two flattened truncated cones applied baſe to baſe. The average length is rather more than $\frac{1}{3}$ of an inch. As the ſhape of the ſeed is ſomewhat flat, it is obvious that it has two croſs diameters, one of which is longer than the other. The greater of theſe two, for the ſake of diſtinction, may be called the *breadth*, and the ſmaller the *thickneſs*. To know the ſhape, therefore, it is only neceſſary to know the length, breadth, and thickneſs, with ſome preciſion. This is given in the fourth compartment of the preceding Table, under three reſpective columns. Theſe columns were filled up in the following manner:

Twenty ſeeds of each kind of Grain were ſelected and put into the ſcale of a balance, and in the other ſcale were put their average weight, eſtimated from the average weight of a ſingle ſeed. If the 20 were heavier than the average weight, ſome of the largeſt were picked out, and as many ſmaller added; and this was perſiſted in till the equilibrium was rendered complete. If they were lighter than the average weight, the ſmalleſt were picked out, and the equilibrium obtained by ſubſtituting larger ones. The average length, breadth, and thickneſs of theſe 20 ſeeds, were conſidered as affording a pretty juſt average of the whole. Each of them was carefully meaſured in each dimenſion, to the thouſandth part of an inch, by an inſtrument made on purpoſe, and the average of each dimenſion ſtruck.

The inſtrument uſed conſiſted of two braſs rulers fixed upon a braſs plate, meeting together at one extremity, but at the other half an inch diſtant from each other, and of courſe forming the two ſides of a triangle. The length of the rulers from the apex to the baſe of the triangle, was ſuch as to admit them to be divided into 500 equal parts, which were numbered regularly from the apex to the baſe, 1, 2, 3, 4, 5, &c. to 500, which laſt number was at the extremity of the rulers fartheſt from the apex. It is obvious that the diſtance between the two rulers, at each of theſe diviſions, was juſt as many thouſandth parts of an inch as were denoted by the number attached to the diviſion. Hence, by gently puſhing a Barley-corn up between the rulers till it was ſtopped, its length, breadth, or thickneſs was reſpectively indicated. Nothing was more eaſy than to meaſure the breadth and thickneſs of a Barley-corn with this inſtrument, with all the requiſite exactneſs: but the length was not ſuſceptible of the ſame preciſion; for as there remains, at both extremities, leſs or more of the empty huſk, and as this portion differs in different Corns, the length varies accordingly, unleſs it be removed; but to remove it with preciſion is extremely difficult, if not impoſſible. After various trials, we ſucceeded beſt in getting conſtant reſults by giving each Corn a gentle ſqueeze, holding it lengthways between the finger and thumb; but we do not conſider the lengths as aſcertained with accuracy, though, when taken this way, they approximate conſi-

derably

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derably to it. It was not thought neceſſary to give the dimenſions of every kind of Grain, as the variations were inconſiderable; but a ſufficient number of examples have been ſelected.

4. *Equality* of ſize is conſidered as one of the moſt valuable qualities in Grain, eſpecially when intended for malting. On the other hand, the more unequal Grain is, in this reſpect, ſo much the worſe it is ſuppoſed to be. The fifth head of the preceding Table is intended to give ſome notion of the degree in which the Grain ſubjected to Experiment poſſeſſed this deſirable quality. It conſiſts of four columns; the firſt, titled *weight of a Corn*; the ſecond, *length*; the third, *breadth*; and the fourth, *thickneſs*. Each of theſe is again ſubdivided into three columns, titled reſpectively, *greateſt*, *leaſt*, and *difference*. Theſe columns were conſtructed in the following manner:

It has been already obſerved, that the average weight of a Corn was eſtimated by weighing 5,000 grains troy. This was done at ten different times, 500 grains troy being weighed each time. From each of theſe weighings, the average weight of one Corn was eſtimated by counting the numbers in 500 grains. The number inſerted in the column, marked *ſize* (of the Table) was obtained by ſtriking the average of the whole ten. Now the average weight of a Corn differed ſomewhat in the different trials. The column, marked *weight of a Corn*, gives the *greateſt*, or *leaſt*, average obtained, and the difference between them. The other columns give the *greateſt*, and *leaſt*, *length*, *breadth*, and *thickneſs*, in any of the 20 ſeeds that were meaſured, with the amount of the difference.

From this account it is obvious, that under the head of *inequality of ſize*, it was not an object to aſcertain the greateſt and the ſmalleſt Barley-corns that occurred in any parcel, (a piece of information which, if attained, could have afforded little or no information) but rather the greateſt and ſmalleſt ſizes which *commonly* occurred.

It has been affirmed by many perſons, that the quality of Barley is very much affected by the ſoil on which it is raiſed, and that the ſoil affects it, by communicating a greater or ſmaller portion of earthy and ſaline matters. It was thought worth while to put this notion, that the quantity of earthy matter varied with the ſoil, to the teſt of Experiment. For this purpoſe, three ſpecimens were ſelected, raiſed in very different parts of Great Britain, namely, *Firſt Norfolk Barley*, *Firſt Edinburgh Barley*, and *Firſt Aberdeen Bigg*. The ſame weight of each of theſe was burned, with the proper precautions, to a white *aſh*. The weight of this aſh was ſo very nearly the ſame in each of the three trials, that the difference may be ſafely aſcribed to unavoidable errors, to which Experiments of that nature are expoſed. In each caſe, the *aſh* amounted, very nearly, to $\frac{1}{50}$th of the weight of the Grain from which it was procured. Theſe aſhes were ſubjected to a chemical analyſis: the conſtituents were the ſame very nearly, and may be ſtated, in round numbers, as follows:—

About $\frac{1}{3}$ ſelica, tinged with iron
$\frac{1}{3}$ phoſphate of lime
$\frac{1}{3}$ phoſphate of potaſh

1

The reſult of theſe trials is not favourable to the notion, that the earthy and ſaline parts of Barley are liable to variation from the ſoil in which it grows.

Such are the properties of the different kinds of Grain which were ſubjected to the proceſſes of malting, brewing, and diſtillation, in order to aſcertain their reſpective values. Let us now proceed to give an account of each of theſe proceſſes in ſucceſſion.

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II. THE MALT.

AS the primary object of the whole inveſtigation, was a compariſon between the value of Malt made from different kinds of Grain, and as this depends, in ſome meaſure at leaſt, upon the ſkill of the Maltſter, and upon the mode of conducting the proceſs, an examination of the whole buſineſs of malting was deemed neceſſary. There was the fulleſt opportunity of obſerving every ſtep, as no fewer than 76 different parcels of Grain were malted during the courſe of the Experiments, all of which were examined with minute attention.

The proceſs of malting conſiſts in inducing Grain to germinate, and ſtopping the progreſs of vegetation after it has proceeded to a due length, by expoſing the Malt to heat. Grain can be made to yield both ale and ſpirits without being malted; but the liquors ſo produced are of inferior quality; the ale eſpecially, though not deficient in tranſparency, has a taſte which renders it exceedingly diſagreeable. As the flavour of ſpirits is not of ſo much conſequence as their ſtrength, the Diſtiller frequently uſes raw Grain; but the excellence of ale, depending upon its fine flavour, the Brewer is under the neceſſity of having recourſe to Malt.

The whole proceſs of malting may be divided into four ſtages:

I. The Grain is ſteeped in water.

II. It is placed in a heap called *the couch.*

III. It is ſpread thin upon the malt-floor, and regularly turned ſeveral times a day.

IV. It is dried upon the kiln.

I. The Steep.

I. The Maltſters have a kind of ſquare chamber, generally at one extremity of their barn, lined with ſtone or lead, and uſually ſunk below the level of the floor. This chamber they fill with water to the proper height, and then let down, or throw into it, the Grain to be malted. Here it muſt remain covered with water for a period (as regulated by law) of not leſs than 40 hours.

When the Grain is thrown into the "ſteep," it is directly ſtirred about and levelled, to allow the Exciſeman to aſcertain its quantity. The heavy Grain ſinks to the bottom, while the refuſe and light ſeeds ſwim upon the ſurface, and are uſually ſkimmed off to ſave Duty.

The time which different Malſters allow the Grain to remain in the "ſteep," varies conſiderably. They ſeem to be regulated not ſo much by any determinate plan, as by cuſtom, or perhaps, in ſome caſes, by caprice. Scotch Maltſters, in general, give their Barley much more of the ſteep than the Engliſh, who frequently juſt make out the legal time. In our Experiments, the time varied from 40 hours to 118, according to the ſeaſon, the kind of Grain, and the fancy of the Maltman. The rule uſually followed, is to let the Barley remain till it is ſo ſoft, that its ends can be ſqueezed together between the fingers. The time neceſſary to produce this ſoftneſs, differs conſiderably in different ſpecimens. New Barley requires to be ſteeped longer than old, and Bigg requires much leſs time than Barley. Some Maltmen change the water once or twice while the Grain is in the ſteep, others not at all; nor has any material difference been obſerved in the Malt, which ever plan is followed.

Changes in the Steep.

Three remarkable circumſtances occur while the Grain is in the ſteep. 1. The water takes different ſubſtances from the Grain, diſſolves them, and carries them off. 2. The Grain gradually imbibes water, ſwells in conſequence, and increaſes in bulk. 3. A quantity of the air called *carbonic acid gas*, is formed and emitted.

1. Matter carried off by the water.

1. In leſs than 24 hours after the commencement of the ſteeping, the water gradually acquires a yellow or brown colour, and likewiſe the peculiar ſmell and taſte which ſtraw imparts to that liquid. If this water be evaporated to dryneſs, it leaves behind it a blackiſh brown reſidue of a diſagreeable bitter taſte. This is the matter taken up from the Grain. A particular account of its nature and

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and properties would be foreign to the preſent inveſtigation. Suffice it to ſay, that a part of it is analogous to the ſubſtance called *extractive* by Chemiſts, but that it alſo contains other bodies, and that the ſalt called *nitrate of ſoda*, is always preſent. The matter taken up by the water, appears to proceed from the huſk of the Grain, rather than the kernel; for if the huſk be removed, the water takes up ſcarcely any thing, and does not acquire the high colour communicated by the entire Grain. The quantity of this matter varies conſiderably in different parcels of Grain; but it is ſeldom leſs than $\frac{1}{100}$th of the weight of the Grain ſteeped, and ſeldom exceeds $\frac{1}{50}$th of that weight. Bigg always gives a much higher colour, and a greater quantity of matter to water than Barley, owing, we preſume, to its having a greater proportion of huſk, and a darker colour.

Grain imbibes water.

2. The Grain begins very ſpeedily to imbibe water. It is ſenſibly increaſed in bulk, after it has been a few hours in the ſteep. This augmentation of bulk continues to advance pretty regularly till it has reached its *maximum*. It is aſcertained by the increaſe of the depth of the barley, meaſured by the gauging rod.

The quantity of ſwell is in ſome degree regulated by the time of ſteeping; but it depends alſo on the nature of the Grain, and, of courſe, varies much even where the time is the ſame. The greateſt ſwell obſerved in the proceſſes under our inſpection, was nearly 38 per cent. and the ſmalleſt 9½ per cent. that is to ſay, 100 buſhels of Grain in the one caſe, were increaſed by ſteeping to 138, in the other to 109½. The ſwell of the Engliſh Barley was greater than that of the Scotch; and the ſwell of Barley is uſually greater than that of Bigg. In our trials, the average ſwell of 100 buſhels of

Engliſh Barley was to - 124. 5 or $\frac{1}{4}$th nearly.
Scotch Barley - - - - 121. 5 - $\frac{1}{5}$th.
Bigg - - - - - - 117. 6 - $\frac{1}{6}$th.

The greateſt ſwell from 100 in Engliſh Barley was to 138 *
Scotch Barley - - 126
Bigg - - - - - 123.

The leaſt from 100 in Engliſh Barley, to 116
Scotch Barley - 115
Bigg - - - - 109

The time of ſteeping in theſe laſt inſtances was ſhort, only 52 hours for Barley and 40 for Bigg; the malting having been conducted by an Engliſh maltſter, as practiſed in England. If theſe be excluded, then the *minimum* ſwell, in all the other caſes, is from 100, in

Engliſh Barley, to - 121
Scotch Barley - - 119
Bigg - - - - - 112

The quantity of water imbibed by the Grain is ſtill greater than what is indicated by the ſwell, nor does it ſeem to be proportional to the ſwell. The greateſt quantity imbibed in our proceſſes was 62 per cent. and the leaſt 36. That is to ſay, 100 pounds of Barley, when firſt taken out of the ſteep, being dried, or wiped with a cloth ſo as not to wet the fingers, will, in the firſt caſe, weigh 162 pounds, and in the ſecond, 136 pounds. Barley appears to imbibe more water than Bigg, and in our trials the Engliſh Barley imbibed more water than the Scotch.

The average increaſe of weight from 100, was,
in Engliſh Barley, to - - - - - - - 153
in Scotch Barley, to - - - - - - - 145
in Bigg, to - - - - - - - - - 141

The greateſt, in Engliſh Barley, to - - 162
Scotch Barley, to - - 152
Bigg, to - - - - - - 147

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* The ciſtern in which this gauge was taken, was ſo wide that preciſion could not be obtained.

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The leaſt in Engliſh Barley, to - - - - 144
Scotch Barley, to - - - - 138
Bigg, to - - - - - - - - 138

Theſe laſt were malted by an Engliſhman, and the Grain had got a *minimum* of ſteep.

In the ſame kind of Grain, the worſt quality, or the weakeſt Corn, undergoes the greateſt increaſe of weight by ſteeping. Thus it was the Eſſex 3d of the Engliſh that increaſed to 162; the Eaſt Lothian 3d. that increaſed to 152: and theſe were, perhaps, the worſt of all thoſe on which the compariſon was made. It is not eaſy to compare the Bigg, as in moſt of the trials in which the increaſe of weight was examined, that Grain was decidedly overſteeped.

If the ſpecific gravity of the Grain be taken juſt after it has come out of the ſteep, it will be found conſiderably leſs than in the dry Grain, owing obviouſly to the ſwell or abſorption of water. Some notion may be formed of this change by the following Table, exhibiting the ſpecific gravity of different ſorts of Barley and Bigg, both in the ſtate of raw Grain, and when juſt out of the ſteep.

TABLE V.

GRAIN.		Specific Gravity Raw.	Specific Gravity out of Steep.	Weight after ſteeping the raw Grain being 100.	Bulk after ſteeping the raw Grain being 100.	Diminution of Specific Gravity.
Eſſex - - - - - -	3	1.290	1.219	162	130	0.071
Kent - - - - - -	1	1.250	1.216	154	125	0.034
Norfolk - - - -	3	1.290	1.223	154	122	0.067
Eaſt Lothian - - -	2	1.333	1.212	146	122	0.121
Lanark Bigg - - -	1	1.250	1.121	147	111	0.129
Mid Lothian - - -	1	1.290	1.262	144	123	0.048
Kirkcudbright Bigg -	2	1.265	1.176	142	115	0.089
Eaſt Lothian - - -	1	1.333	1.194	140	121	0.139
Perth Bigg - - -	1	1.227	1.212	139	117	0.015

Too great reliance, however, ought not to be placed on this Table, on account of the difficulty of taking the ſpecific gravity of dry Barley with accuracy, and of drying it, when taken out of the ſteep, to the ſame degree in all caſes; yet we ſee from it, that the ſwell in Barley is greateſt, when the increaſe of weight is greateſt; but that the ſame rule does not hold in Bigg. Hence the water abſorbed muſt be in a more condenſed ſtate, or the vacuities greater in Bigg than in Barley. As to the ſpecific gravity, it would be hazardous to draw any other concluſion, than that it is diminiſhed in all caſes by ſteeping. When Grain has imbibed a quantity of water, the bulk of it is leſs than that of the Grain and of the water taken ſeparately. This is proved by a fact to which there was no exception in a great variety of trials. If a quantity of Barley be put into a glaſs veſſel ending in a narrow graduated tube, and the veſſel filled with water, after an interval of 24 hours, the water will be found to have ſubſided a little, ſo that an additional quantity is requiſite to bring it to the ſame height again in the tube. In theſe trials, care was always taken to prevent any error that might ariſe from the eſcape of air-bubbles.

If Barley taken out of the ſteep be expoſed to the open air, it loſes all the additional weight in about 10 days; but the diminution does not ſtop here; for the Grain becomes gradually lighter than at firſt.

To form ſome notion of this, 960 grains troy of Barley were ſteeped in water for 48 hours, and 960 grains of the ſame Barley were heated on a ſteam bath for the ſame period. This was done in April.

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The ſteeped grain weighed - - -	1298,	having gained	338	grains.
The dried - - - - - - - - -	840,	having loſt -	120	d°.
In ten days, the ſteeped grain weighed	968,	having loſt -	330	d°.
The dried - - - -	907,	having gained	67	d°.
In a month, the ſteeped grain weighed	926,	loſt -	372	d°.
The dried - - - -	909,	gained	69	d°.
In two months the ſteeped grain weighed	901,	loſt -	397	d°.
The dried - - - -	921,	gained	81	d°.

This change of weight will be better underſtood by the following Tables:

1. The Grain ſteeped.

Original weight - - - - - - -	100
Weight when taken out of the ſteep	135
D° expoſed to the air for 10 days	100.8
D° after a month - - - - -	96.4
D° after two months - - - -	93.8

2. The Grain dried.

Original weight - - - - -	100
Weight when newly dried -	87.5
D° after ten days expoſure to the air - - - - - -	94.5
D° after a month - - - -	94.7
D° after two months - - -	95.9

Carbonic acid gas emitted.

3. It is not eaſy to eſtimate the quantity of carbonic acid evolved during the ſteeping of Grain, though it is certainly conſiderable. A great part of it remains in the ſteep water. Hence that liquid renders lime-water turbid, and yields gas when boiled. A great portion of this gas lies entangled among the Grain, and is not extricated till the latter is removed. From ſome trials, made with a ſmall portion of Barley ſteeped in glaſs cylinders, we conclude that Grain, ſteeped the uſual time, emits, on an average, about $\frac{1}{3000}$th part of its weight of this gas. But this eſtimate is not to be conſidered as preciſe, having been made only on one kind of Grain. The emiſſion of this gas continues for ſome time after the Grain is expoſed to the air. This circumſtance explains, in ſome meaſure, why a Barley-corn, when expoſed to the air after being ſteeped, becomes ſo much lighter than it was when in the ſtate of raw Grain. If new ſteeped Barley be thrown up into a cylinder filled with mercury, and inverted in a baſon with mercury, it emits about twice its bulk of that gas. If continued in this ſituation, the Grain is killed and acquires a cheeſy ſmell, but neither moulds nor putrifies.

Such are the changes which take place while the Grain continues in the "ſteep."

II. The Couch.

II. After the Grain has been drained, many Maltmen let an additional quantity of water flow into the ciſtern, and immediately draw it off again, in order to waſh the Barley, and remove a ſlimy matter which uſually appears in warm weather. The Grain is then thrown out of the ſteep upon the floor, where it is carefully formed into a rectangular heap about 16 inches deep, called *the couch*. In this ſtate it commonly continues for 26 hours. The form is made as regular as poſſible, to enable the Exciſeman to aſcertain the quantity; for it is by the bulk of the couch that the Malt Duty is uſually levied. The Barley in the couch always occupies more ſpace than before; the weight of the Grain preventing the ſwell, in ſome meaſure, from reaching its full extent in the ciſtern. The increaſe of bulk, however, in the couch diminiſhes in proportion as the quantity of Grain increaſes: In very ſmall quantities, the difference is enormous. To give an example; three cubic inches of Barley, put into a cylindrical glaſs veſſel graduated to tenths of an inch, were covered with water, and allowed to remain for 96 hours. The ſwell was only 0.8 of an inch or $\frac{1}{10}$th of the whole; but upon turning the cylinder upſide down, ſo as to ſhake the Barley to the other end, it now occupied the bulk of 4.2 cubic inches, indicating a ſwell of more than $\frac{1}{3}$: at the ſame time 0.2 inches of air ſeparated. In this caſe, the ſwell of the Grain was tripled, merely by moving it from one place to another. In experiments, however, conducted on a large ſcale, the increaſe produced by this cauſe is much leſs. Indeed, the bulk of the Grain in the ſteep, as aſcertained by the gauging rod, ſometimes, though ſeldom, exceeds the bulk in the couch; but we are diſpoſed to aſcribe this variation to errors unavoidable in gauging, and not to any diminution of bulk occaſioned by throwing the Grain out of the ſteep.

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Suppoſing the bulk of the raw Grain put into the ſteep to be 100, the greateſt bulk in the couch in our trials was 138, the leaſt 110.6, the general average 121.6.

Exciſemen always take the *beſt* gauge, as they term it, either in the couch or ſteep,

TABLE VI.

GRAIN. 1ſt QUALITIES.	Original Bulk of Grain.	Bulk, by beſt Gauge, in Steep or Couch.	Produce in Malt.	Malt charged Duty.	Difference per Cent.
ENGLISH.					
Norfolk - - - - - - -	100	123.0	109.5	98.4	
Norfolk - - - - - - -	100	121.5	104.5	97.2	
Kent - - - - - - - -	100	128 0	111.2	102.4	
Kent - - - - - - - -	100	119.7	106.3	95.8	
Suffolk - - - - - -	100	123.7	101.6	98.5	
Suffolk - - - - - - - -	100	116.8	100.8	93.4	
Average - - - - -	100	122.1	105.6	97.6	8
2d QUALITIES.					
Norfolk - - - - - -	100	129.6	109.2	103.7	
Norfolk - - - - - -	100	122.0	103.9	97.6	
Suffolk - - - - - -	100	137.9	107.6	109.5	
Kent - - - - - - - -	100	133.2	109.2	106.5	
Kent - - - - - - - -	100	125.6	105.3	100.4	
Average - - - - -	100	129.6	107.0	104.4	026
3d QUALITIES.					
Norfolk - - - - - -	100	128.2	106.4	102.5	
Norfolk - - - - - -	100	127.1	104.5	101.6	
Eſſex - - - - - - -	100	134.5	106.5	107.6	
Eſſex - - - - - - -	100	126.3	105.8	101.0	
Eſſex - - - - - - -	100	128.0	102.1	102.4	
Eſſex - - - - - - -	100	120.5	97.6	96.4	
Average - - - - -	100	127.4	103.4	101.9	1.9

GRAIN. SCOTCH.	Original Bulk of Grain.	Bulk by beſt Gauge.
1ſt QUALITIES.		
Berwick and Haddington -	100	119.8
Haddington - - - - -	100	121.0
Haddington - - - - -	100	121.0
Linlithgow - - - - -	100	118.7
Perth - - - - - -	100	127.3
Fife - - - - - - - -	100	125.3
Angus - - - - - -	100	123.8
Edinburgh - - - - -	100	123.8
Edinburgh - - - - -	100	116.7
Average - - - -	100	119.
2d QUALITIES.		
Berwick and Haddington -	100	119.
Haddington - - - - -	100	125.
Perth - - - - - - -	100	114.
Fife - - - - - - - -	100	119.
Average - - - - -	100	119.
3d QUALITIES.		
Berwick - - - - - -	100	115.
Haddington - - - - -	100	120.
Linlithgow - - - - -	100	113.
Linlithgow - - - - -	100	121
Fife - - - - - - -	100	117.
Angus - - - - - - -	100	120
Average - - - - -	100	118

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eep, that is to ſay, the gauge, which gives the greateſt bulk of grain in buſhels. hey ſubtract one-fifth from the bulk thus found, conſider the number obtained s equal to the quantity of clean Malt produced, and charge the duty accord-ngly. The following Table, conſtructed from our trials, will ſhew how far the ccuracy of this method may be depended on.

TABLE VI.

Produce in Malt.	Malt charged Duty.	Difference per Cent.
100.6	95.8	
109.4	96.8	
103.1	96 8	
106.2	94.9	
102.4	101.8	
100.1	100.2	
103.6	100.6	
98.6	99.0	
102.7	93.3	
102.9	97.6	5.3
100.9	95.5	
103.2	100.6	
96.9	91.3	
94.0	95.6	
98.7	95.7	3
98.2	92.1	
101.6	96.0	
92.3	90.8	
93.4	96.8	
91.5	94.0	
101.1	96.6	
96.3	94.4	1.9

GRAIN. BIGGS.	Original Bulk of Grain.	Bulk by beſt Gauge.	Produce of Malt.	Malt charged Duty.	Difference per Cent.
1ſt QUALITIES.					
Dumfries - - - - -	100	112.0	97.6	89.6	
Dumfries - - - - -	100	132.8	97.9	106.2	
Lanark - - - - - -	100	121.6	103.3	96.3	
Perth - - - - - - -	100	120.9	102.9	95.7	
Perth - - - - - -	100	120.7	99.1	95.5	
Perth - - - - - -	100	112.8	97.4	89.2	
Aberdeen - - - - -	100	127.3	100.7	101.8	
Aberdeen - - - - -	100	125.6	93.9	100.5	
Aberdeen - - - - -	100	114.5	94.1	91.6	
Aberdeen - - - - -	100	124	98.7	99.2	
Average - - - - -	100	121.2	99.1	97.0	2.1
2d QUALITIES.					
Kirkcudbright - - - -	100	119.5	101.2	95.6	
Ayr - - - - - - -	100	114.2	101.1	91.3	
Angus - - - - - -	100	127.4	96.8	101.9	
Angus - - - - - -	100	121.6	94.5	97.2	
Mearns - - - - - -	100	121.3	96.5	97.0	
Average - - - - -	100	120.8	98.1	96.6	1.5
3d QUALITIES.					
Kirkcudbright - - - -	100	110.6	94.5	88.4	
Aberdeen - - - - -	100	123.1	105.0	98.4	
Average - - - -	100	116.8	99.7	93.4	6.3

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From this Table it appears, that the quantity of Malt charged with Duty according to the preſent regulation, is, generally, under the real produce, though, in ſome caſes, it exceeds it a little. The average of the preceding Table gives as a reſult, that the Malt ſo charged with Duty, is about 3½ per cent. below the actual produce.

While the Grain is in the couch, the moiſture gradually exhales, and the temperature begins to increaſe, at firſt very ſlowly, and almoſt imperceptibly; but, at laſt, with great rapidity, unleſs checked. During the 26 hours, however, that it lies untouched, it ſeldom gets more than 2° or 3° above the heat of the barn. In general, the difference becomes ſooner perceptible, when the temperature of the barn is low, as at 40°, than when it is 50° or higher.

This evolution of heat is probably ſimilar to what happens when moiſt hay is ſtacked, and is owing to a ſimilar cauſe. It is accompanied by the abſorption of oxygen gas from the air. This abſorption is not very rapid; and it ſoon ceaſes altogether, unleſs the air be renewed, and the carbonic acid gas, which the grain continues to give out, be diſſipated. For Grain encloſed in a glaſs veſſel, ceaſes to vegetate in a very ſhort time, unleſs the air be renewed.

III. The Floor.

III. To check the too rapid progreſs of temperature, and alſo to expoſe the whole of the Grain equally to the influence of the air, the Maltman turns it over, and at the ſame time ſpreads it thinner upon the floor. At firſt, the depth is diminiſhed only a very little; but the Malt is at laſt brought to the thickneſs of 3 or 4 inches. Every part of it is kept at as equal a thickneſs as poſſible, and turned over regularly twice, thrice, or four times a day, or oftener according to circumſtances: the object being to keep the heat as nearly as poſſible at the ſame degree. This treatment continues for ten days or a fortnight, or till the Grain is ſufficiently malted.

Changes on the Floor.

While the Malt is on the floor, a variety of intereſting changes happen. 1. The Grain, at a certain period, becomes moiſt and exhales at the ſame time an agreeable odour. 2. Soon after this period, the roots begin to make their appearance. 3. The *plumula, future ſtem,* or *acroſpire,* begins to ſwell, and gradually advances under the huſk from the ſame end of the ſeed where the roots are obſerved to ſpring, till it reaches the other extremity. 4. The kernel becomes drier, friable, opake, white, and ſweet-taſted. 5. Each grain of Corn loſes a certain portion of its weight.—The whole ſecret of malting depends upon the proper regulations of theſe changes. This is done chiefly by, 6. Keeping the temperature as equal as poſſible; which, again, depends on, 7. The time and number of the turnings. It will be neceſſary to take a ſhort view of each of theſe particulars, in order to form preciſe notions of the nature of malting.

1. The Sweating.

1. After the Grain has been caſt out of the ſteep and put into the couch, it gradually becomes dry externally, the moiſture that adhered being either diſſipated, or abſorbed. The temperature in the meantime gradually riſes, and in about 96 hours, will uſually be found to have increaſed about 10 degrees. This riſe of temperature in the heap, depends in ſome meaſure on the ſtate of the atmoſphere. If the air has become colder ſince the period of *caſting*, the Malt does not become ſo warm as it would otherwiſe do; while, on the other hand, if the air has become milder, the temperature of the Malt experiences a correſponding increaſe. Ten degrees may be ſtated as nearly the medium of the different experiments. The ſmalleſt riſe obſerved was 5°, the greateſt 18°; the moſt common from 8° to 12°. It muſt be obſerved however, that the riſe of temperature depends greatly upon the choice of the Maltſter, who can check it at pleaſure, by turning over the Grain and ſpreading it thinner upon the floor.

About 96 hours after "caſting," the Grain which had become ſeemingly quite dry on the ſurface of the huſks, turns again ſo moiſt, that it will wet the hand if we thruſt it into the malting heap. The appearance of this moiſture, which happens regularly after the Malt has been ſome days on the floor, is called *ſweating* by the Maltſters: it continues for one day or two, and then diſappears. During its continuance a pretty ſtrong odour is exhaled, rather agreeable, and not unlike that of apples. If at this period, a portion of the Malt be diſtilled in a ſteam bath, a little ſpirits will be found in the liquid which comes over. They may be made more apparent by mixing this liquid with ſulphuric acid, and diſtilling a ſecond time.

Unleſs

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Unleſs the Malt be turned pretty frequently, as ſoon as the ſweating comes on, the temperature increaſes with great rapidity. In one caſe, the turning was omitted for about 14 hours, and the temperature was obſerved as high as 80°. The following Table will ſhew the heat of various parcels of Malt at the time of caſting, and when the ſweating commenced.

TABLE VII.

GRAIN MALTED.	Temperature at Caſting.		Temperature at Sweating.		Increaſe of Temperat.	Change of Temperature in Barn.	
	Malt.	Barn.	Malt.	Barn.		Increaſe.	Diminution.
Norfolk - - - - - 1ſt	40°	38°	58°	48°	18°	10°	—
Kent - - - - - 1ſt	49	50	54	46	5	-	4
Norfolk - - - - 2d	45	45	57	45	12	0	0
Kent - - - - - - 2d	44	45	52	46	8	1	—
Norfolk - - - - 3d	47	47	57	46	10	-	1
Eſſex - - - - - - 3d	48	45	55	47	7	2	—
Haddington - - - - -	42	41	47	32	5	-	9
Edinburgh - - - - 1ſt	51	51	62	50	11	-	1
Linlithgow - - - - -	50	49	60	51	10	2	—
Haddington - - - - 2d	44	43	54	43	10	0	0
Haddington - - - - 3d	50	51	64	51	14	0	0
Lanark Bigg - - - -	43	-	55	37	12	-	—
Aberdeen Bigg - - -	55	55	62	53	7	-	2
Perth Bigg - - - - -	54	46	60	54	6	8	—
Angus Bigg - - - -	51	52	62	57	11	5	—
Kirkcudbright Bigg - -	45	47	57	45	12	-	2

2. The ſhooting of the radicles or commings.

2. It is juſt about the time of the ſweating that the roots begin to make their appearance; each, at firſt, like a ſmall white prominence at the bottom of the ſeed, which ſoon divides itſelf into three rootlets, and at laſt into four, five, or even ſeven. Thoſe roots are, at firſt, very ſoft and tender; but, in a few days, they begin to wither and to acquire hardneſs. Many of them are broken off during the turning of the Malt, and, in that caſe, new roots generally ſucceed them, at leaſt in the earlieſt ſtages of the proceſs of malting.

When the radicles have divided themſelves into three roots, and have acquired ſome length (which uſually happens in one, two, or three days after their appearance, according to circumſtances) the apple-like ſmell goes off, and is ſucceeded by another not unlike that of the *common ruſh*, when newly pulled. This ſmell continues during the whole time that the Malt is on the floor; unleſs it be overpowered by a peculiar mouldy ſmell, which happens only when the Grain is bad, and contains ſeeds incapable of germinating; or when a part of the Malt has been bruiſed, during the turning, from the careleſsneſs of the workmen.

The length, number, and progreſs of the roots called "*commings*" by the Maltſters, vary much according to circumſtances. It is well known that, when Barley is ſown in a good ſoil, of a proper texture, the roots continue moderately ſhort, and the chief effort of vegetation ſeems to be directed to the advancement of the ſtem; but, in looſe ground, the former ſhoot out to a greater length, and the latter makes a leſs rapid progreſs. In malting again, the roots have a much greater tendency to lengthen than even in the pooreſt or moſt open ſoils. Accordingly, if allowed to take their courſe on the malting floor, in a moiſt, warm heap, they grow to a great length; in ſome caſes, not leſs than two or three inches.

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The prime object of the Maltſter is to check this inordinate length, and this he accompliſhes by frequently turning over the Malt. By ſuch treatment, its temperature is kept uniform, and the moiſture is equally exhaled. There is, however, a conſiderable difference in the practice of Maltſters in this reſpect. Some allow the roots to get to 7-8ths of an inch long; others never wiſh to ſee them above half that length. As the roots are afterwards ſeparated from the Malt and thrown away, and as their length does not contribute to the progreſs of malting, the latter method ſeems preferable.

In Bigg, the roots are commonly fewer than in Barley. The number in the former is uſually between three and ſix, whereas in Barley they commonly amount to between four and ſeven. But as the preciſe number depends upon a variety of circumſtances, which it is impoſſible to appreciate beforehand, this minute, and perhaps not very conſtant difference, would form a deceitful mark of diſtinction between Bigg and Barley.

3. The plumula or acroſpire.

3. The fourth or fifth day from the "caſting," and about a day after the ſprouting of the roots, the rudiment of the future *ſtem* may be ſeen to lengthen. It riſes from the ſame extremity with the root, and advancing within the huſk, at laſt iſſues from the oppoſite end of the ſeed, and aſſumes the form of a green blade of graſs. But the proceſs of malting is brought to a concluſion ſome time *before* the ſtem has made ſo much progreſs as to burſt the huſk. This rudiment of the ſtem is called by Botaniſts *plumula*, but Maltſters give it the name of *acroſpire*.

The progreſs of the acroſpire is, at firſt, very rapid, like that of the roots. By the eighth day after "caſting," it will have uſually reached rather more than one-half the length of the Grain. But after this time, its progreſs becomes much more ſlow, ſo that frequently another week elapſes, or even more, before it has made its way to near the end of the ſeed, when it is underſtood to be proper to finiſh the malting; were the Malt allowed to lie longer on the floor, the progreſs of the acroſpire becomes again rapid, ſo that it ſoon puſhes its way out of the huſk and puts on a leafy appearance. When Grain is in the earth, the progreſs of the acroſpire is much more uniform and rapid. In that caſe, the ſupply of nouriſhment is abundant and conſtant, whereas, on the Malt floor, the very contrary is the caſe.

4. Changes in the ſtate of the kernel.

4. As the acroſpire ſhoots along the Grain, the appearance of the kernel, or mealy part of the Corn, undergoes a conſiderable change. The glutinous and mucilaginous matter, which perhaps bind together the ſtarchy particles, is taken up and removed. The colour becomes white, and the texture ſo looſe that the kernel crumbles to powder between the fingers. This change is progreſſive, it begins at that end of the ſeed where the roots are, and gradually proceeds onward to the other extremity; ſo that one portion of the kernel often appears in a friable ſtate, while the other ſtill retains the appearance of raw Barley. It is the common opinion of Maltſters, that this change of the Grain always keeps pace with the acroſpire; each ſeed being altered as far as the point of the acroſpire extends, and *no further*. And this opinion has been rather confirmed by our obſervation.

The whole object of malting is to produce this change in the kernel. As ſoon as it has taken place, the ſeed is no longer in the ſtate of raw Grain, but of Malt. The kernel is originally compoſed chiefly of ſtarch, the particles of which ſeem to be enveloped by a ſpecies of gluten and mucilage. This cement (or, perhaps, cellular membrane) is taken up and expended, in the firſt place, for the purpoſes of vegetation, and thus the ſtarch is ſet at liberty, not however in the ſtate of common ſtarch, for its taſte is ſomewhat ſweetiſh, and it is completely ſoluble in water, which is not the caſe with the other. The object of malting being to procure this modified or altered ſtarch, the proceſs ought to be ſtopped as ſoon as it is fully diſengaged and prepared. If the proceſs has been rightly conducted, this object will be attained, as already mentioned, by the time the acroſpire has come within a little of the end of the ſeed; but if it proceed farther, a ſudden and very conſiderable loſs occurs. Shortly after the acroſpire has made its way out of the ſeed, the ſtarchy matter undergoes a farther change, becomes milky, and is very ſoon abſorbed; leaving nothing but the empty huſk.

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The time that the Malt lies on the floor, varies with the kind of Grain, and with the mode of conducting the operation. In our trials, the longeſt time, when the Malt was to be brewed into Ale, was about twenty days, and the ſhorteſt, about twelve. But for diſtillation, the malting is, with great judgment, not carried ſo far as it is by the Brewers; ten days, and ſometimes only eight days on the floor, being thought ſufficient.

5. Loſs of weight.

5. While the Malt lies on the floor, each Corn loſes a certain portion of its weight. A part of this loſs is only apparent, and occaſioned by the exhalation of the moiſture which had been imbibed in the ſteep; but beſides this, there is alſo a real loſs of weight.

If a given weight of the Corn, 500 grains troy, for example, while malting, be taken daily from the floor, weighed accurately, and then dried upon a ſteam bath till it ceaſes to loſe weight; the loſs at firſt will be conſiderably more than two-thirds of the weight; but as the malting advances, the loſs becomes leſs, and, at laſt, approaches very nearly to two-thirds. This gradual diminution will be ſeen from the following Table:

TABLE VIII.

	Weight loſt in drying 500 Grains Troy.				Weight loſt in drying 500 Grains Troy.		
GRAIN MALTED.	Firſt Day.	Eighth Day.	Laſt Day.	GRAIN MALTED.	Firſt Day.	Eighth Day.	Laſt Day.
Norfolk - 1ſt Quality	209	211	201	Norfolk - 3d Quality	218	217	202
Haddington 1ſt D° -	204	210	202	Eſſex - - 3d D° -	234	233	217
Lanark Bigg 1ſt D° -	209	203	199	Haddington 3d D° -	222	210	199
Norfolk - 2d D° -	218	215	203	Kent - - 1ſt D° -	219	222	205
Kent - - 2d D° -	223	218	- -	Edinburgh - 1ſt D° -	216	202	192
Haddington 2d D° -	- -	215	200	Perth Bigg - - - -	220	215	196

This Table gives us the following Average:

Loſs of Weight by drying,

1ſt day - - - 218, or nearly 43½ per cent.
8th day - - - 211 - - - 42
Laſt day - - - 201 - - - 40

Now, ſince the ſame weight of Malt ſuffers a ſmaller loſs of weight by ſteam-drying, after it has lain ſome time on the floor, than when newly caſt, and as the greateſt part of the weight loſt on a ſteam-bath, can only be aſcribed to moiſture exhaled, it follows that a portion of moiſture muſt ſeparate from the Malt while on the floor; but the real amount of the loſs from the exhalation of moiſture, cannot be fairly deduced from the preceding Table.

If, after having weighed 500 grains troy of Malt, taken off the malt-floor during every day of the proceſs, we reckon the number of ſeeds contained in this weight, we ſhall find that this number gradually increaſes as the "flooring" advances. This will appear evident from the following Table:

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TABLE IX.

GRAIN.	Corns in 500. Grains Wt, while on the Floor.			GRAIN.	Corns in 500 Grains Troy of Malt, while on the Floor.		
	Firſt Day	Eighth Day.	Laſt Day.		Firſt Day.	Eighth Day.	Laſt Day.
Norfolk - - - - - 1	495	546	545	Norfolk - - - - 3	499	542	566
Haddington - - - 1	481	491	515	Eſſex - - - - - - 3	520	541	564
Lanark Bigg - - - 1	626	626	674	Haddington - - - 3	520	559	568
Norfolk - - - - - 2	504	520	536	Kent - - - - - - 1	491	497	522
Kent - - - - - - 2	493	540	- -	Edinburgh - - - 1	486	506	533
Haddington - - - 2	493	516	550	Perth Bigg - - - -	614	627	670

This Table gives us the following average of the weight of a Corn, while on the floor:

1ſt day - - - - -	1,000
8th day - - - - -	956
Laſt day - - - - -	914

Thus it appears, that about one-half of the whole loſs ſuſtained on the floor, happens during the firſt eight days.

As far as the loſs of weight is concerned, the flooring may be divided into three periods. The firſt of theſe continues from the caſting of the Grain, till the acroſpire has advanced half way along the Barley-corn, which happens uſually about the eighth day. The ſecond begins about the eighth or ninth day, and continues commonly till the end of the twelfth. The third reaches from the end of the twelfth day till the end of the flooring. During each of theſe periods, the Grain is conſtantly loſing weight, and the loſs goes on pretty uniformly, except at the end of each period, which is marked by a ſudden and unuſually great diminution. The following Table, which gives the average of the firſt two maltings examined, will give ſome notion of the rate of this curious progreſſion:

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TABLE X.

Days of Flooring.	Number of Corns in 500 G^{r} Troy.	Average Weight of a Corn.	Probable Rate of Diminution of Weight.
1	560	100	100.0
2	561	99.8	99.7
3	554	101	99.4
4	548	102.2	99.1
5	567	98.8	98.8
6	563	99.4	98.5
7	567	98.3	98.2
8	579	96.7	96.6
9	580	96.5	96.3
10	586	95.9	96.0
11	581	96.4	95.7
12	587	95.4	95.4
13	589	95.1	95.1
14	606	92.4	93.2
15	606	92.4	92.9
16	606	92.4	92.6
17	605	92.8	92.3
18	609	92.0	92.0

Though pretty much the ſame progreſſion was obſerved in all the maltings, yet it is impoſſible to compare them with each other, and ſtrike a general average, becauſe ſcarcely in any two was the progreſs exactly alike. Some reached the concluſion of the firſt period by the end of the ſeventh day, as the two for inſtance from which the preceding Table was formed, but the greater number not till the end of the eighth day, and ſeveral not till the end of the ninth. There was the ſame diverſity in the time of the concluſion of the ſecond period, and the commencement of the third. The anomalies obſervable in the Table, are to be aſcribed to errors unavoidable in ſingle Experiments, and would have diſappeared, had it been practicable to take a general average of the numerous trials made. From a compariſon of twelve different maltings, there is reaſon to believe, that the loſs of weight per day amounts to about three or four thouſandth parts, according to the rapidity with which the proceſs is going on; that the rate is nearly equable, except at the end of the periods above-mentioned, at which time there is commonly a ſudden leap, amounting to about 2 per cent.; after which the diminution proceeds as before. The fourth column of the preceding Table was added, to give a more diſtinct conception of the progreſs of this diminution of weight, and of the interruption of the progreſſion at the end of each period. It was conſtructed on the ſuppoſition, that the rate of diminution is equable, and is not to be conſidered as the exact average of our obſervations, but as the numbers which come neareſt to it.

If the malting be continued after the acroſpire has reached the fartheſt extremity of the Corn, the loſs of weight ſuſtained is ſtill greater than what has been ſtated above, and it proceeds at a much greater rate. Hence appears the great impropriety of allowing the acroſpire to advance too far. It is in the power of a Maltſter, merely by permitting his Grain to remain a day or two longer on the

floor

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floor than is neceſſary, to make the Malt of any ſort of Grain whatever as unproductive as he pleaſes. No great ſtreſs, therefore, ought to be put upon trials of the comparative values of different parcels of Grain, from the produce of the Malt made from them, unleſs the proper precautions be taken to ſtop the malting, when the loſs of weight in each is the ſame, or when that proceſs has been carried to the ſame due length. Bigg is much more apt to undergo a great loſs of weight about the end of the flooring, than Barley; becauſe, in ſimilar circumſtances, the acroſpire in the former lengthens more rapidly than in the latter*. Indeed, the circumſtance now mentioned, ought never to be overlooked in trials on the comparative value of that ſpecies of Grain. Were the malting ſtopped whenever the acroſpire gets about half way between the ſwell and the extremity of the Corn, or when it has proceeded about three-fourths of its length, as there is reaſon to believe it ought to do, the real loſs of weight ſuſtained by the malting Grain, while on the floor, would not exceed 5 per cent.

6. The Temperature.

6. The loſs of weight, as well as the progreſs of the malting, depends much upon the temperature; two things reſpecting which require attention. 1. To keep it as equal as poſſible; and 2. To keep it at the proper pitch, neither too high nor too low. Unleſs the firſt precaution be attended to, the progreſs of the Malt is very unequal, ſome parts being fully ready, before others have advanced half way. This inequality is attended with a great loſs of weight, becauſe many of the fartheſt advanced Corns muſt be ſacrificed to the progreſs of the reſt. It is chiefly prevented by keeping the thickneſs of all parts of the Malt as equal as poſſible, and by turning it over without delay, whenever an inequality of temperature can be detected in any portion of it.

A high temperature is more injurious at the beginning "of the flooring," than after the Malt has made ſome progreſs. Should the heat be in exceſs, the radicles advance too rapidly while the kernel does not undergo the wiſhed-for change, but becomes clammy, like birdlime; a condition which is moſt apt to ſupervene in the early ſtages of the proceſs, when the Grain is very moiſt. Hence the proper temperature may be judged of pretty correctly, from the rootlets or "commings." If they be pretty equal, and do not exceed half an inch in length, we may conſider the temperature as having been proper; but when they lengthen ſuddenly and unequally, there muſt have been an exceſs of heat.

In our trials, the heat varied conſiderably; but the beſt Malt made with us, had, for the average of its temperature, 56°, varying between 52° and 60°. The Engliſh Maltſters (at leaſt if ſome trials made by an Engliſhman, who profeſſed to follow the mode practiſed in England, were accurate) uſually keep the temperature of their Malt higher than this. The average in three maltings, after the Engliſh mode, was 59°, and the temperature was often as high as 67°, ſometimes even 70°, and was never obſerved to be under 57°. Barley was found in our trials to ſupport a higher temperature, without injury, than Bigg. Indeed it is probable, that the ſmaller the Grain malted, the lower is the temperature at which it ſhould be kept, in order to make the moſt of it.

7. The turning.

7. It is by turning the Malt on the floor, that the temperature is regulated, as well as by ſpreading it thicker or thinner. Some Maltſters turn their Malt, at ſtated periods only; but that practice is obviouſly abſurd, as the neceſſity of turning varies with the progreſs of the malting, and with the ſtate of the weather. It ought to be obſerved, that Malt is often injured by the feet of the workmen while turning it, and that the Grain thus bruiſed, immediately becomes mouldy, and may injure the look and ſmell of the whole, and doubtleſs alſo affects its flavour.

IV. The Kiln.

IV. Such are the moſt remarkable circumſtances that happen while the Grain is on the floor, the moſt important part of the whole proceſs of malting. When the Grain is thought to be ſufficiently malted, the farther progreſs of vegetation is ſtopped by putting it on the kiln. The kiln conſiſts of a chamber

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* This obſervation will help to explain ſome anomalies which occurred in reſpect to Bigg, both in the brewing and diſtillery.

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floored with plates, full of very ſmall holes, or with wire, or haircloth. The Malt is ſpread upon this floor to the depth of from 3 to 6 inches, and a very moderate fire of charcoal is kindled in an apartment below it. The heated air paſſes up through the Malt, and makes its eſcape by the roof of the kiln, where there is an aperture for the purpoſe. During its paſſage, it becomes loaded with moiſture, and thus gradually dries the Malt. For a conſiderable time, the fire is kept ſo low as not to heat the Malt higher than the temperature of the human body. As the drying advances, the temperature is gradually raiſed till it riſes to 140° or even higher, according to the object in view. The colour of the liquor to be produced from the Malt depends upon the temperature at which the latter is dried. If that liquor is wiſhed to be pale, the Malt is dried at a low heat; but if brown, like *porter*, the heat is conſiderably increaſed. We have obſerved the temperature of the Malt often as high as 160° and 170°, and on one occaſion at 186°. Indeed we have reaſon to believe that Malt is ſometimes dried at a heat little leſs than that of boiling water. Even pale Malt may have been expoſed to a heat of 170°, and Malt may be made brown at a lower temperature: for it is not ſo much the temperature, as the ſuddenneſs with which it is raiſed, while the Malt is ſtill moiſt, which alters the colour: the eaſe with which the ſoluble part of Malt alters its colour and its taſte, when expoſed to heat, conſtitutes one of its moſt remarkable characters. This facility of change or decompoſition is conſiderably increaſed by the preſence of moiſture. If pale Malt be properly dried, it does not loſe the power of vegetating; but this power is deſtroyed if the heat be too ſuddenly urged.

The time during which the Malt is on the kiln, varies with the temperature and the quantity of Malt dried, from forty to eighty hours, which were the extremes in our Experiments. While upon the kiln, the Malt is occaſionally turned.

V. The cleaning of the Malt.

V. The laſt proceſs is the cleaning of the Malt. While ſtill warm upon the kiln, it is uſually trodden upon by the workmen, to ſeparate the radicles or *commings*; which are at that time brittle, but ſoon become tough by abſorbing moiſture. The commings thus detached, are afterwards ſeparated by paſſing the Malt through the common fanners; or, inſtead of this mode of cleaning, an inſtrument called a *harp*, well known to the Brewers, is employed. The quantity of rootlets and broken parts of huſks, thus detached from the malted Grain, varies according to circumſtances, but is always conſiderable.

The Malt thus obtained weighs about one-fifth leſs than the raw Grain from which it was produced; but this diminution of weight varies ſomewhat according to the temperature of the kiln; the leaſt in our trials was 19 per cent. the greateſt 27, the average, about 23.

A great part of this loſs of weight is to be aſcribed to the kiln-drying; and conſiſts of nothing elſe than the moiſture which previouſly exiſted in the raw Grain, and of which it would have been deprived by the heat of the kiln, as well as the Malt. In order to aſcertain how much of the loſs was owing to this cauſe, the raw Grain ſhould have been kiln-dried and weighed juſt before it was put into the ſteep. In that caſe, the difference between the weight of the Malt and of the kiln-dried Grain, would have indicated the quantity of loſs of ſubſtance really ſuſtained by Grain during the proceſs of malting. As this method was not practicable in purſuing trials on a large ſcale, we had recourſe to another, leſs preciſe indeed, but ſufficient to give us a notion of the loſs of weight actually ſuſtained by the Malt. Portions of the raw Grain, and of the newly-dried Malt, were expoſed to the ſame temperature upon a ſteam-bath. The loſs of weight ſuſtained by the Grain being called a, and that by the Malt b, it is obvious, that $a-b$ repreſents the loſs of weight which the Grain would have ſuſtained, had it been dried on the kiln at the ſame temperature as the Malt. This ſubtracted from the difference between the weight of the raw Grain and the Malt, gave the real loſs of weight ſuſtained by the Grain during the proceſs of malting.

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The difference between the raw Grain and the Malt may be called the *apparent loſs*, as much of it was owing to moiſture, which the Malt gradually imbibes again when expoſed to the air.

Loſs ſuſtained by malting.

In our trials, the loſs of weight proceeding from the diſſipation of moiſture, varied from 8 to 18 per cent. and the real loſs from 6 to 12 according to the proceſs. The average loſs from the diſſipation of moiſture, may be conſidered as 14 per cent. and the average real loſs may be ſtated at 8 per cent.

About $\frac{4}{10}$ths of this loſs muſt be aſcribed to the commings which are ſeparated by cleaning the Malt. If they be deducted, the loſs ſuſtained in malting does not exceed an average of 5 per cent. If we reckon the loſs in the ſteep at 1½ per cent. there will remain 3½ per cent. for loſs upon the floor; but of this, ½ per cent. may be ſafely reckoned for waſte, conſiſting chiefly of ſmall corns and commings, loſt during the kiln drying, and the tranſporting of the Malt from place to place. From this ſtatement, it follows that, at an average. 100 lbs of barley yield 78 of newly dried Malt; ſo that there is a loſs of about 22 lbs. Of this loſs, 14 pounds are to be aſcribed to moiſture, a conſiderable portion of which the Malt receives again by ſtanding. The real loſs conſiſts of the remaining 8 pounds, which are thus accounted for.

Loſt in ſteep - - -	1½
Loſt on floor - - -	3
Commings - - -	3
Waſte - - - -	½
Total	8

The bulk of the Malt generally exceeds that of the raw Grain, though this does not always happen. The average, for inſtance, of all our maltings of Scotch Barley gave almoſt exactly bulk for bulk, yet, in ſome inſtances, 100 buſhels of Barley yielded 109 of Malt. Others, of courſe, muſt have fallen as much ſhort. The average of the Engliſh Barley was 105 buſhels of Malt from 100 of Grain; that of the Bigg 99. The greateſt produce was 112 buſhels of Malt from 100 of Barley; the leaſt 93. Probably, too, the inequality might be owing partly to the unequal degrees in which, in different caſes, the Malts, or both the Grain and Malts, had been cleaned. In our trials, the Bigg did not deviate ſo far from equality as the Barley.

The weight of the Malt varies alſo conſiderably; but in general a buſhel of good Malt, when newly dried, weighs about three-fourths of a buſhel of the raw Grain.

Tables of the maltings.

Having finiſhed the general account of the proceſs of malting, it will now be proper to mention the reſult of the different trials made upon the various parcels of Grain ſubjected to Experiment. This reſult is contained in the following Tables, which exhibit thoſe particulars of the malting of moſt of the parcels of Grain, that appear of the greateſt conſequence.

Theſe Tables conſiſt of 18 columns. The firſt column contains the names of the parcels of Grain malted; the ſecond, the weight of each parcel per buſhel in pounds avoirdupoiſe; the third, the number of buſhels of each parcel put into the ſteep; the fourth, the buſhels of ſwimmings or light ſeeds ſkimmed off the ſurface; the fifth, the buſhels of Grain really ſteeped, obtained by ſubtracting column fourth from column third; the ſixth, the weight of the ſwimmings; the 7th, the weight of the Grain really ſteeped, obtained by ſubtracting column ſixth from the weight of the Grain put into the ciſtern; the eighth, gives the number of hours that each parcel was ſteeped; the ninth, the increaſe of bulk produced by ſteeping, ſuppoſing the original bulk in all caſes to have been 100; the tenth, the ſwell in the couch, calculated likewiſe on the ſuppoſition that the original bulk was 100; the eleventh, the number of days the Malt lay on the floor; the twelfth, the quantity of clean Malt obtained in buſhels; and the thirteenth

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thirteenth, the weight of that Malt per buſhel, when newly dried. The fourteenth, gives the apparent loſs of weight by malting, or the loſs including the diſſipated moiſture, ſuppoſing the original weight 100. It was obtained by comparing the weight of the Malt obtained with that of the Grain ſteeped.

The next four columns give the relative quantities of Malt in bulk and weight, obtained from given quantities of Grain; the fifteenth, gives the buſhels of Malt yielded by 100 buſhels of Grain; the ſixteenth, the buſhels of Malt yielded by 100 pounds avoirdupois of Grain; the ſeventeenth, gives the pounds avoirdupois of Malt obtained from one buſhel of Grain; and the eighteenth, the pounds of Malt from one pound of Grain.

Table No. XI. exhibits the maltings of Grain of the firſt quality. Table No. XII. of Grain of middle quality; and the Table N° XIII. of Grain of the worſt quality.

TABLE XI.—MALTINGS OF GRAIN

GRAIN.	Weight per Buſhel.	Buſhels meaſured out.	Swimming in Buſhels.	Buſhels really ſteeped.	Swimmings in Pounds Avoirdupois.	Weight of Grain really ſteeped.	Hours in Steep
ENGLISH.							
Norfolk	50.375	150	1.4	148.60	43.18	7509.82	116
Norfolk	50 375	150	1.75	148.25	43.00	7513.50	93.7
Kent	49.750	90	1.96	88.09	56.45	4421.05	86
Kent	49.914	90	1.75	88.25	40.50	4442.63	52
Suffolk	50.508	150	2.68	147.32	84.15	7494.00	49
Suffolk	50.859	72	1.28	70.72	29.44	3632.40	44
Average	50.297	- - -	- - -	- - -	- - -	- - -	73.4
SCOTCH.							
Berwick and Haddington	53.093	114.75	1.23	113.52	23.87	6068.60	119
Haddington	52.190	60	0.5	59.50	13.75	3117.50	92
Haddington	52.190	75	0.3	74.70	11.26	3902.80	112
Linlithgow	51.062	66	0.56	65.44	18.34	3352.81	109
Perth	50.226	66	0.75	65.25	21.00	3293.95	57
Fife	51.539	148	1.62	146.38	40.00	7578.78	81
Angus	49.312	66	1.68	64.32	44.37	3210.25	80
Edinburgh	52.164	111	1.50	109.50	41.37	5748.82	76
Edinburgh	52.164	90	1.25	88.75	34.47	4660.29	52.5
Average	51.549	- - -	- - -	- - -	- - -	- - -	86.5
BIGGS.							
Dumfries	47.00	75	3.28	71.72	77.00	3448.00	73
Dumfries	47.726	80	2.03	77.97	59.96	3758.16	80
Lanark	48.562	150	2.67	147.33	79.65	7204.72	80
Perth	48.585	100	2 00	98.00	61.84	4796.66	104
Perth	48.562	98	3.25	94.75	97.45	4661.68	73
Perth	48.562	90	3.00	87.00	81.06	4289.56	45
Aberdeen	48.226	90	2.09	87.91	55.81	4284.57	74
Aberdeen	48.562	150	2.68	147.32	88.19	7196.19	89
Aberdeen	48.312	90	2.25	87.75	57.50	4291.62	58
Aberdeen	49.172	90	2.26	87.74	60.75	4364.72	57
Average	48.327	- - -	- - -	- - -	- - -	- - -	73

F FIRST QUALITY.

well Cent. teep.	Swell per Cent. in Couch.	Days on Floor.	Clean Malt in Bushels.	Weight of clean Malt per Bushel.	Apparent Loss of Weight per Cent.	Bushels of Malt.		Pounds of Malt.	
						From 100 Bushels, Grain.	From 100 Pounds, Grain.	From 1 Bushel, Grain.	From 1 Pound, Grain.
6	23.08	18	162 75	36.58	20.0	109.5	2.17	40.063	0.793
- -	21.5	16	155.00	38.40	21.2	104.5	2.06	40.152	0.788
5	28.0	12	98.00	34.88	23.0	111.2	2.22	38.816	0.773
5.7	19.7	17	93.87	35.76	25.0	106.3	2.11	38.926	0.755
- -	23.3	13	149.75	40.56	21.0	101.6	2.00	41.227	0.810
- -	16.8	13	71.31	39.11	23.2	100.8	1.96	39.435	0.768
3.9	22.06	14.8	- - -	37.55	22.2	105.6	2.09	39.736	0.781
- -	19.8	18	114.18	39.60	25.4	100.6	1.88	39.840	0.746
	- - -	20	64.50	38.06	21.0	109.4	2.07	41.618	0.787
	21.	19	77.00	39.18	23.0	103 1	1.97	40.386	0.773
.5	18.7	9	69.5	39.09	19.0	106.2	2.07	41.520	0.810
- -	27.3	- - -	66.86	38.18	22.49	102.4	2.03	39.130	0.775
- -	25.3	14	146.54	38.80	25.07	100.1	1.93	38.843	0.749
.8	23.8	8	66.60	36.76	24.0	103.6	2.07	38.074	0.763
.	23.8	14	108.	41.92	21.0	98.6	1.88	41.345	0.787
.8	16.7	16	91.12	40.24	22.0	102.7	1.95	41.319	0.787
.7	19.6	13	- - -	39.09	22.6	102.9	1.98	40.23	0.775
- -	12.0	13	70.00	36.81	23.5	97.6	2.03	35.930	0.765
.8	32.8	8	76.31	37.70	23.5	97.9	2.03	36.899	0.765
.0	21.6	18	152.25	36.44	23.0	103.3	2.11	37.637	0.770
.0	20.9	13	100.94	34.44	27.5	102.9	2.10	35.374	0.724
.0	20.7	13	93.86	37.57	24.5	99.1	2.01	37.237	0.757
.4	12.8	15	84.75	36.53	28.0	97.4	1.97	35.586	0.722
.0	27.3	8	88.50	38.37	21.0	100.7	2.06	38.633	0.793
- -	25.6	10	146.25	36.03	26.8	99.3	2.13	35.770	0.732
-	14.5	10	82.60	39.00	25.0	94.1	1.93	36.712	0.751
- -	24.0	- - -	86.58	39.44	21.7	98.7	1.98	38.906	0.783
3	21.2	10.8	- - -	37.23	24.4	99.1	2.03	36.868	0.756

TABLE XII—MALTINGS OF GRAIN,

GRAIN.	Weight per Buſhel.	Buſhels meaſured out.	Swimmings in Buſhels.	Buſhels of Grain really Steeped.	Swimmings in Pounds Avoirdupois.	Weight of Grain really Steeped.	Hours in Steep.
ENGLISH.							
Norfolk - - - - - - - - - -	50.57	150	2.56	147.44	58.00	7527.50	115
Norfolk - - - - - - - - - -	51.00	150	3.50	146.50	70.87	7579.20	88
Suffolk - - - - - - - - - - -	48.845	80	3.12	76.87	85.00	3822.49	87
Kent - - - - - - - - - - -	50.062	80	2.25	77.75	62.87	3942.13	84
Kent - - - - - - - - - - -	49.945	150	4.43	145.57	112.37	7385.24	8
Average - -	50.084	- -	- -	- -	- -	- - -	9
SCOTCH.							
Berwick and Haddington - - -	50.53	126	1.50	124.50	44.00	6323.00	97
Haddington - - - - - - - -	52.26	150	1.25	148.75	32.81	7807.03	118
Perth - - - - - - - - - - -	48.19	66	1.90	64.10	48.37	3132.51	64
Fife - - - - - - - - - - -	48,51	100	1.45	98.55	36.12	4834.25	47
Average - -	49.87	- -	- -	- -	- -	- - -	81.
BIGGS.							
Kirkcudbright - - - - - - -	46.87	150	4.56	145.44	112.16	6109.10	8
Ayr - - - - - - - - - - -	47.94	150	2.84	147.16	77.00	7113.62	66.2
Angus - - - - - - - - - -	47.03	108	3.12	104.87	85.87	4993.50	8
Angus - - - - - - - - - -	47.39	150	4.34	145.66	119.72	6989.46	5
Mearns - - - - - - - - - -	47.91	126	1.82	124.18	51.87	5985.27	5
Average - -	47.42	- -	- -	- -	- -	- - -	70.

OF SECOND QUALITY.

Swell in Steep r Cent.	Swell in Couch per Cent.	Days on Floor.	Clean Malt in Bufhels.	Weight of Malt per Bufhel.	Apparent Lofs of Weight per Cent.	Bufhels of Malt.		Pounds of Malt.	
						From 100 Bufhels Grain.	From 100 Pounds Grain.	From 1 Bufhel Grain.	From 1 Pound Grain.
24.	29.6	15	161.00	38.437	18	109.19	2.113	41.972	0.822
- -	22.0	13	152.13	37.562	24.6	103.86	2.007	39.013	0.754
37.9	37.9	9	82.77	36.500	21	107.67	2.165	39.299	0.790
27.8	33.2	9	84.87	39.125	16	109.16	2.165	42.612	0.842
- -	25.6	12	153.00	36.875	23.46	105.31	2.072	38.823	0.765
29.9	29.6	13	- - -	37.699	20.61	107.03	2.104	40.343	0.794
- -	19.4	16	125.69	38.501	23.46	100.95	1.990	38.865	0.765
22	25.8	19	153.50	37.298	27.	103.19	1.960	38.490	0.733
- -	14.2	10	62.12	39.531	21.6	96.91	1.983	38.310	0.784
- -	19.6	11	92.68	40.039	23.24	94.04	1.917	38.669	0.767
22	19.7	14	- -	38.842	23.82	98.77	1.962	38.583	0.762
15	19.5	15	147.25	36.400	26.50	101.24	2.128	36.853	0.744
- -	14.2	16	148.75	37.832	20.89	101.08	2.091	38.330	0.791
21	27.4	8	101.53	37.547	24.70	96.81	2.033	36.349	0.763
- -	21.6	13	137.73	38.570	24.80	94.55	1.971	36.083	0.751
- -	21.3	13	119.87	37.550	24.80	96.52	2.004	36.238	0.752
18.	20.8	13.	- -	37.579	24.33	98.06	2.045	36.770	0.760

TABLE XIII.—MALTINGS OF GRAIN,

1.	2.	3.	4.	5.	6.	7.	8.
GRAIN ENGLISH.	Weight per Buſhel.	Buſhels meaſured out.	Swimmings in Buſhels.	Buſhels really Steeped.	Swimmings in Pounds Avoirdupois.	Weight of Grain really Steeped.	Hours in Steep.
Norfolk - - - - - - - - -	51.937	150	1.75	148.25	46.0	7744 64	91
Norfolk - - - - - - - - -	51.625	150	3.47	148.53	60.5	7663.70	84
Eſſex - - - - - - - - - - -	47.633	90	3.59	86.44	107.2	4179.72	98
Eſſex - - - - - - - - - - -	48.414	100	3.87	96.12	119.6	4721.77	82
Eſſex - - - - - - - - - - -	48.000	100	3.50	96.50	84.0	4716.00	73
Eſſex - - - - - - - - - - -	46.410	100	6.25	93.75	159.0	4482.37	45
Average - - - - - - -	49.004	- - -	- - -	- - -	- - -	- - -	78
SCOTCH.							
Berwick - - - - - - - - -	48.854	150	2.22	147.78	64.0	7263.63	74
Haddington - - - - - - -	48.969	150	2.90	147.10	78.0	7267.30	97
Linlithgow - - - - - - -	46.940	66	2.78	63.22	77.2	3021.14	47
Linlithgow - - - - - - -	46.375	66	2.00	64.00	57.5	3003.25	49
Fife - - - - - - - - - -	49.744	66	0.75	65.25	20.5	3262.22	56
Angus - - - - - - - - - -	46.965	66	2.50	63.50	61.7	3037.82	53
Average - - - - - - -	47.974	- - -	- - -	- - -	- - -	- - -	62
BIGGS.							
Kirkcudbright - - - - - -	44.722	150	6.09	143.90	235.6	6473.00	65
Aberdeen - - - - - - - - -	44.086	40	2.25	37.75	66.0	169.74	77
Average - - - - - - - - -	44.404	- - -	- - -	- - -	- - -	- - -	71

THIRD QUALITY.

9.	10.	11.	12.	13.	14.	15.		16.	
vell Steep Cent.	Swell in Couch per Cent.	Days on Floor.	Clean Malt in Buſhels.	Weight of Malt. in Buſhels.	Apparent Loſs of Weight per Cent.	Buſhels of Malt.		Pounds of Malt.	
						From 100 Buſhels of Grain.	From 100 Pounds of Grain.	From 1 Buſhel of Grain.	From 1 Pound of Grain.
22	28.2	12	157.75	36.68	23	106.41	2.037	39.033	0.747
- -	27.1	14	153.14	37.61	24.8	104.50	1.998	38.774	0.759
30	34.5	13	92.06	35.12	23	106.55	2.202	37.423	0.770
2.4	26.3	10	101.50	36.86	21	105.83	2.149	38.923	0.794
- -	28.0	10	98.56	35.66	25.5	102.13	2.090	36.417	0.745
- -	20,5	11	91.26	38.67	21	97.66	2.036	37.772	0.790
4.8	27.4	11	- - -	36.76	23	103.84	2.085	38.057	0.767
- -	15.2	14	145.14	37.31	25.4	98.21	1.998	36.656	0.746
20	19.7	15	149.43	36.82	24.3	101.58	2.056	37.399	0.757
- -	13.6	10	58.34	40.16	22.5	92.28	1.931	37.057	0.775
1	20.7	9	59.78	39.09	23.5	93.41	1.990	35.980	0.767
- -	17.5	11	59.72	40.81	25.3	91.52	1.831	37.353	0.747
- -	20.8	10	64.22	36.41	23.0	101.13	2.114	36.817	0.770
- -	17.9	11	- - -	38.43	24.0	96.35	1.986	36.877	0.760
- -	10.6	14	136.00	35.03	26.4	94.5	2.101	33.108	0.736
22	23.1	8	39.62	33.50	22.0	105.0	2.334	35.164	0.782
- -	16.8	11	- - -	34.26	24.2	99.7	2.217	34.136	0.759

The following Table, N° 14, exhibits the average reſults of the three preceding ones.

2. Report of Experiments on Malt made from Barley and Scotch Bigg.

TABLE XIV.—AVERAGE OF

GRAIN.	Weight per Buſhel.	Swimmings, per Buſhel.		Hours in Steep.	Swell in Steep.
		Buſhels.	Pounds.		
ENGLISH.					
1ſt Quality - - - - - - - -	50.297	.01541	0.4226	73.4	18.9
2d Quality - - - - - - - -	50.084	.02600	0.6379	92	29.9
3d Quality - - - - - - - -	49.004	.03250	0.8352	78	24.8
Average - -	49.795	.02463	0.6319	81.1	24.5
SCOTCH.					
1ſt Quality - - - - - - - -	51.549	.01151	03517	86.5	- - -
2d Quality - - - - - - - -	49.870	.01380	0.3649	81.6	- - -
3d Quality - - - - - - - -	47.974	.02332	0.6349	62.0	- - -
Average - -	49.797	.01623	0.4505	76.3	- - -
BIGGS.					
1ſt Quality - - - - - - - -	48.327	.02518	0.7100	73.0	17.3
2d Quality - - - - - - - -	47.420	.02438	0.6529	70.45	18.0
3d Quality - - - - - - - -	44.404	.04389	1.0460	71.0	- - -
Average - -	46.717	.03115	0.8029	71.48	17.6

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Report of Experiments on Malt made from Barley and Scotch Bigg.

THE WHOLE MALTINGS.

Swell in Couch.	Days on Floor.	Weight of Malt per Buſhel.	Apparent Loſs of Weight per Cent.	Buſhels of Malt.		Pounds of Malt.	
				From 100 Buſhels Grain.	From 100 Pounds Grain.	From 1 Buſhel Grain.	From 1 Pound Grain.
22.06	14.8	37.55	22.2	105.6	2.09	39.736	0.781
29.60	13	37.699	20.6	107.0	2.10	40.340	0.794
27.40	11	36.76	23.0	103.8	2.08	38.057	0.767
26.30	12.9	37.336	21.9	105.5	2.09	39.378	0.780
19.60	13	39.09	22.6	102.9	1.98	40.230	0.775
19.70	14	38.842	23.8	98.7	1.96	38.580	0.762
17.90	11	38.43	24.0	96.3	1.98	36.880	0.760
19.00	12	38.787	23.5	99.3	1.97	38.560	0.766
21.2	10.8	37.23	24.4	99.1	2.03	36.868	0.756
20.8	13.0	37.79	24.3	98.7	2.04	36.770	0.760
16.8	11.0	34.26	24.2	99.7	2.217	34.136	0.759
19.6	11.6	36.356	24.3	99.0	2.095	35.924	0.758

FROM this Table we learn that the average weight of the Engliſh
and

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Report of Experiments on Malt made from Barley and Scotch Bigg.

and Scotch Barley uſed for malting, was very nearly the ſame, but the Scotch Barley *was cleaner, as it yielded only 1½ per cent. of ſwimmings,* while the Engliſh Barley yielded 2½ per cent. The average weight of the Bigg is about 6 per cent. leſs than that of the Barley. It appears to have been worſe cleaned than the Engliſh Grain, for the ſwimmings which it yielded amounted to 3 per cent. This increaſe of ſwimmings muſt not be aſcribed to weak Corn mixed in the Bigg, for the average weight of the ſwimmings in all the three kinds of Grain was nearly the ſame, as will appear from the following ſtatement:

The average weight of a buſhel of ſwimmings, from

Engliſh Barley, was - -	25.6 libs. avoirdupois.
Scotch Barley - - -	27.7
Bigg - - - - -	25.7

Thus it was the Scotch Barley that yielded the heavieſt ſwimmings, and of courſe contained the greateſt proportion of weak Grain.

The Engliſh Barley experienced a greater ſwell than the Bigg or Scotch Barley. The average proportions were

Engliſh Barley - - -	100
Scotch Barley and Bigg -	73

In other reſpects there does not appear to exiſt any great difference between the Barley and Bigg, as far as malting is concerned, except what ariſes from the difference in weight. But Malt is made in order to procure from it ale and ſpirits. Its value, of courſe, depends upon the relative quantity of theſe liquors which it is capable of producing. Let us proceed therefore to examine the relative qualities of the different Malts when ſo employed.

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III. THE BREWING.

IT has been long believed in Scotland, that Ale of the very beſt quality may be made either from Barley or Bigg Malt, provided the Grain be good, and the proceſs of Malting properly conducted. The reſult of our trials was a confirmation of this opinion; ſome of our very beſt ales being the produce of the Bigg. The value of ale, as a marketable commodity, depends chiefly upon its tranſparency, taſte, flavour, and ſtrength, qualities which cannot well be appreciated with exactneſs, and which depend as much upon the ſkill of the Brewer as upon the Malt. But as all the different kinds of Grain under examination, may be made to yield ale of the ſame goodneſs, the queſtion of comparative value can only be anſwered by aſcertaining which yields the greateſt quantity of ale of a given ſtrength. The ſtrength of ale however depends upon the ſtrength of the wort from which it is prepared, and the ſtrength of the wort depends upon the quantity of ſolid matter taken up from the Malt. Hence the determination of the comparative value of the different kinds of Malt, as far as Brewing is concerned, reſolves itſelf into this very ſimple queſtion, What ſpecies of Malt yields the greateſt portion of ſoluble matter to hot water? As the anſwer to this queſtion is obtained in the firſt part of the proceſs of Brewing, it will not be neceſſary to enter on ſo full a detail reſpecting that operation, as has been done with regard to Malting. The following ſhort ſketch will be ſufficient to explain the Tables, in which the comparative value of the different Malts, when uſed in Brewing, is given.

The Brewers uſually allow their Malt to ſtand for ſome time after it is dried, before they uſe it. During this period it abſorbs moiſture from the atmoſphere, and of courſe increaſes both in bulk and weight. But this increaſe cannot well be appreciated, as it depends very much upon the moiſture or dryneſs of the weather. In all our trials, the Malt was conſtantly meaſured out and weighed, as ſoon as poſſible, after the kiln-drying, and laid aſide in bags, containing four buſhels each. It was always this original weight and bulk that were reckoned upon in every ſubſequent proceſs, whatever change might have taken place in the interval. By long ſtanding, a buſhel of Malt ſometimes increaſes in weight two or three per cent. During grinding, this increaſe is remarkably accelerated. In ſome of our trials, twenty buſhels of Malt weighed juſt before grinding, upon being weighed immediately after, were found to have gained $\frac{1}{200}$th part of their weight.

The proceſs of Brewing may be divided into four parts, which may be diſtinguiſhed from each other by the following names:

I. The Maſhing.
II. The Boiling.
III. The Cooling.
IV. The Fermenting.

1. The Maſhing.

I. The Brewers have a wooden veſſel, uſually cylindrical, called the *maſh-tun*, in which the infuſion of the Malt with the water is made. A ſufficient quantity of hot water is put into it in the firſt place, and the ground Malt being added gradually, is ſtirred about with a kind of *oars*, until it is all completely wetted; the workmen, during this operation, carefully breaking all the clots which they can find. Were this precaution neglected, the Malt within theſe clots would remain dry, and of courſe would give out nothing to the water. This ſtirring proceſs, which is called the *maſh*, is commonly continued about half an hour. A little dry malt flour is then ſtrewed upon the ſurface of the infuſion, to confine the heat as much as poſſible; and the ſurface of the maſh-tun being covered with its lid, and ſometimes with a cloth in addition, the whole is allowed to remain at reſt for about three hours. A cock in the under part of the maſh-tun is then turned, and the water, now impregnated with the ſoluble part of the Malt, is allowed to run out ſlowly into a veſſel, placed on purpoſe to receive it, and called the *underback*. The Brewer occaſionally throws ſome pailfuls of hot

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hot water upon the ſurface of the Malt, and continues to do ſo till the wort iſſuing from the cock has reached the intended degree of weakneſs, or till the wiſhed-for quantity of liquor has been drawn off. The cock at the bottom of the maſh-tun is then ſhut; more hot water is poured upon the Malt, and the maſhing and infuſion are renewed a ſecond time. The wort drawn off from this ſecond infuſion makes a weaker ale. If the Malt be not completely exhauſted, the proceſs may be repeated a third time.

Water uſed.

The quantity of hot water put into the maſh-tun before the Malt, varies according to circumſtances. In our Experiments, its average bulk was about 1-7th more than the bulk of the unground Malt, or in round numbers, about 8½ gallons to the buſhel. Its temperature never varied much from 180°. This was alſo the temperature, very nearly, of the hot water ſprinkled upon the Malt during the running of the wort.

Temperature of the Wort.

The mixture neceſſarily cools ſomewhat during the infuſion. The loſs of temperature depends upon the manner in which the brewing apparatus has been conſtructed: in ſome Breweries the wort, when it begins to flow from the cock of the maſh-tun, is as high as 160°; in others it is allowed to cool to 150°. In one houſe we obſerved it frequently as low as 140°.

The quantity of wort drawn off depends upon the ſtrength which the ale is required to poſſeſs. But even when very ſtrong ales are wanted, the firſt worts, as drawn off, are ſeldom leſs in quantity than the water employed at the beginning to infuſe the Malt. The quantity of ſecond worts varies according to the choice of the Brewer.

The Malt, after the wort has been drained from it, is called *grains* or *draff*. When the proceſs of infuſion has been carried to its utmoſt extent, it conſiſts of little but the huſks of the Barley. Its bulk always exceeds that of the unground Malt, ſeldom more than $\frac{1}{12}$th, unleſs it has been too little ſearched. This increaſe of bulk is owing to the great quantity of water which it retains; in this reſpect reſembling a ſponge.

II. The Boiling.

II. The infuſion of Malt obtained by the preceding proceſs is known by the name of *wort*. It is a tranſparent liquid, of a browniſh colour, more or leſs deep, according to circumſtances. It has a luſcious ſweet taſte, and a peculiar ſmell. It holds in ſolution the ſolid matter, which conſtituted the kernel of the Malt. But the nature of this matter is conſiderably altered by the action of the hot liquid. While in the Malt Corn, its colour is white, its taſte is but ſlightly ſweet, and it is little ſoluble in cold water; but by the action of the hot water, it acquires a ſtronger ſweet taſte, and the property of diſſolving in cold water.

Conſtituents of Wort.

Properties of the ſaccharine matter or extract of Wort.

To the ſubſtance diſſolved by the water, the name of *ſaccharine matter* has been given by the Brewers, becauſe it has ſome reſemblance to ſugar in taſte. By evaporating the wort to dryneſs, this ſaccharine matter may be obtained in a ſeparate ſtate. It aſſumes firſt an appearance not unlike that of molaſſes; but by continuing the heat, it becomes at laſt a brittle brown-coloured maſs, eaſily reducible to powder. In this ſtate it is often uſed under the name of *Extract of Malt*. One of the moſt remarkable properties of this ſaccharine matter, is the great readineſs with which it is diſcompoſed. A heat, not much exceeding 180°. is ſufficient to clear it, at leaſt when it retains a little moiſture. If it be diſſolved in water, and kept a day or two in the temperature of 60°, it begins to emit bubbles of carbonic acid in great abundance, and ſoon runs into acidity. When expoſed to the open air, it ſoon attracts moiſture, and aſſumes the form of a ſoft viſcid maſs, like turpentine, but does not run into a thin liquid. It is extremely ſoluble in water, that fluid at the temperature of 60°, eaſily diſſolving its own weight of it. Its ſpecific gravity is about 1.552, which does not differ much from that of ſugar. It is ſparingly ſoluble in alcohol of ·835, and its ſolubility increaſes as the ſtrength of that liquid diminiſhes.

This ſaccharine matter of Malt differs from ſugar in many particulars; among others, in the following: it is more eaſily diſcompoſed; it is leſs ſoluble in alcohol, and more ſoluble in water; it does not chryſtalize, and it becomes moiſt when expoſed to the air.

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Wort never conſiſts of a ſolution of pure ſaccharine matter in water; other bodies are likewiſe preſent. The moſt remarkable of theſe are *mucilage*, *gluten*, and *ſtarch*. The mucilage may be ſeparated in white flakes, by mixing wort with its own bulk of alcohol. The preſence of ſtarch is indicated by the property which wort has of forming a precipitate with the infuſion of nutgalls. If this precipitate be heated to 120°, a portion of it melts, but another part aſſumes the appearance of birdlime; the firſt portion is a combination of *ſtarch* with the ſolid matter of the infuſion of nutgalls; the ſecond portion, a combination of *gluten* with the ſame ſolid matter.

When the boiled wort has cooled to a certain temperature, a great many white flakes may be ſeen in it, which give it the appearance of curdled milk. Theſe flakes gradually ſubſide and remain upon the *coolers*. The phenomenon reſembles exactly the appearance aſſumed by a boiling hot ſolution of ſtarch mixed with a little nutgalls, when cooled to a certain temperature. Hence it is probable, that it is a combination of ſtarch and the ſubſtance called *tannin*. The flakes collected upon the coolers were always ſo much mixed with hops, that they could not be examined with preciſion. Were the precipitate of the nature ſuppoſed, it would indicate the formation of a little *tannin* during the action of the kiln (or of the hot water) on the Malt, in the ſame way as happens to coffee.

The proportion of theſe ingredients differs very conſiderably in different worts; but this, in our trials, ſeemed to depend more upon the way in which the infuſion was conducted, than upon any difference in the qualities of the Malt. The proportion of ſtarch was uſually greateſt in the firſt worts, while that of the mucilage was greateſt in thoſe that were laſt drawn. The ſaccharine matter alſo diminiſhes ſenſibly towards the end, and at laſt diſappears altogether. The laſt portions of wort become much more eaſily acid than the firſt, and indeed often taſte ſour even when running from the Malt.

Strength of Wort depends upon the proportions of ſaccharine matter.

In all our trials, the ſaccharine matter contained in the wort bore ſo great a proportion to the other ingredients, that they may be overlooked without any great inaccuracy. As far as we can judge, the nature of this ſaccharine matter is the ſame, whether it be drawn from Barley or Bigg Malt. Wort may be conſidered as conſiſting eſſentially of this matter held in ſolution by water. The ſtrength of wort is always proportional to the quantity of matter contained in a given bulk of that liquid. Hence, to aſcertain the comparative values of different Malts, we have only to find how much ſoluble matter each of them will yield when treated with water. Now water, by diſſolving this matter, becomes ſpecifically heavier than before, and the more ſo, the greater the quantity which it has taken up. It was impoſſible to procure pure ſaccharine matter; but, by evaporating wort to dryneſs in the temperature of about 176°, till the reſidue ceaſed to loſe any more weight, we procured *Extract* of Malt in abundance. The reſult of many trials upon this extract from all the different kinds of Malt ſubjected to Experiment was, that the extract from all of them produced the ſame increaſe in the ſpecific gravity of water, when diſſolved in it in the ſame proportion. This ſhewed us, that the ſpecific gravity of the worts might in all caſes be uſed as the meaſure of their relative ſtrengths, and that it indicated, with ſufficient preciſion for practical purpoſes, the quantity of ſolid extract reſpectively contained in them.

The ſpecific gravity increaſes with the ſaccharine matter.

By diſſolving given proportions of dry extract of wort in known weights of water, and taking the ſpecific gravity of the ſolutions at the temperature of 60°, we were enabled to conſtruct the following Table, which indicates, for that temperature, the proportion of ſolid extract by weight, contained in 100 parts by weight of wort of all denſities.

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Quantity of ſaccharine matter indicated by every ſpecific gravity.

TABLE XV.

Specific Gravity.	Extract per Cent.	Specific Gravity.	Extract per Cent.	Specific Gravity.	Extract per Cent.
1.000	0.00	1.048	11.50	1.096	22.31
1.001	0.22	49	11.74	97	22.52
2	0.44	1.050	11.97	98	22.72
3	0.66	51	12.20	99	22.92
4	0.88	52	12.43	1.100	23.13
5	1.09	53	12.66	101	23.36
6	1.31	54	12.89	102	23.62
7	1.52	55	13.12	103	23.84
8	1.75	56	13.34	104	24.05
9	1.96	57	13.57	105	24.24
1.010	2.17	58	13.83	106	24.46
11	2.38	59	14.04	107	24.68
12	2.59	1.060	14.32	108	24.89
13	2.81	61	14.53	109	25.11
14	3.06	62	14.75	1.110	25.31
15	3.32	63	14.96	111	25.52
16	3.57	64	15.18	112	25.75
17	3.84	65	15.39	113	25.97
18	4.05	66	15.60	114	26.18
19	4.25	67	15.81	115	26.38
1.020	4.45	68	16.02	116	26.59
21	4.65	69	16.24	117	26.79
22	4.85	1.070	16.48	118	27.00
23	5.12	71	16.67	119	27.21
24	5.36	72	16.90	1.120	27.41
25	5.58	73	17.13	121	27.61
26	5.93	74	17.37	122	27.80
27	6.19	75	17.65	123	28.00
28	6.54	76	17.86	124	28.19
29	6.80	77	18.09	125	28.39
1.0.30	7.06	78	18.32	126	28.57
31	7.33	79	18.53	127	28.82
32	7.58	1.080	18.78	128	29.00
33	7.83	81	19.01	129	29.27
34	8.09	82	19.24	1.130	29.51
35	8.34	83	19.47	1.140	31.74
36	8.59	84	19.71	1.150	33.88
37	8.84	85	19.94	1.160	35.95
38	9.09	86	20.17	1.170	37.94
39	9.34	87	20.31	1.180	39.95
1.040	9.58	88	20.54	1.190	41.89
41	9.83	89	20.81	1.200	43.90
42	10.07	1.090	21.03	1.210	45.67
43	10.31	91	21.26	1.220	47.31
44	10.55	92	21.47	1.230	49.11
45	10.79	93	21.73	1.235	50.00
46	10.03	94	21.89		
47	11.27	95	22.10		

To verify this Table, a portion of the wort of each Brewing was evaporated to dryneſs, after its ſpecific gravity had been aſcertained. The quantity of dry reſidue obtained, was found to correſpond very well with the numbers in the Table. The ſpecific gravity of ſtrong ale wort (temperature 60°) ſeldom exceeds 1.100, and ſometimes is as low as 1.056. The firſt contains one-fourth of its weight of dry extract; the ſecond, ſomewhat leſs than one-ſeventh. Wort deſigned for ale to be ſold at £.6. per barrel in 1805, furniſhed by a Brewer, was of the ſpecific gravity 1.097. The ſpecific gravity of ſmall beer wort in Edinburgh is often as low as 1.020. In ſome caſes, it is as high as 1.040. The ſtrongeſt wort in our trials was of the ſpecific gravity 1.127.

The inſtrument called a *ſaccharometer*, is merely a hydrometer contrived to ſhew the ſpecific gravity of wort. The degrees upon it however are arbitrary. It is uſually accompanied by a ſcale explaining the value of theſe degrees. A given bulk of wort is pitched upon, namely, a barrel, and the number of pounds avoirdupoiſe of dry extract in that bulk is indicated. The ſaccharometer uſed

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in our Experiments on brewing, was made by Meſſrs. Dring and Fage in London. It was far from being accurate. The value of a degree, or of a pound per barrel, as they have choſen to term it, varied ſomewhat in different parts of the ſcale; but within the range that uſually included the ſtrength of our worts, it was nearly equivalent to *two and a half pounds* per barrel.

The ſtrength of the wort, as it iſſues from the cock of the maſh tun, is never ſo high as what has been mentioned above. After is has been drawn from the Malt, it is conveyed into a copper veſſel, and boiled violently for an hour or two, till it is reduced to the wiſhed-for quantity and ſtrength. By this boiling, the ſpecific gravity increaſes at an average about $\frac{25}{1000}$th parts.

Hops.

In the boiler, the wort is mixed with a quantity of hops, varying according to their quality, and the ſtrength and kind of the ale wanted. In our trials, the proportion varied from two-thirds of a pound to one pound per buſhel of Malt; or about $\frac{1}{40}$th part of the weight of the Malt uſed.

Hops contain two very remarkable ſubſtances. 1. A ſolid oil of a dark green colour, to which they owe their peculiar ſmell and flavour. This oil belongs to the ſpecies called *volatile oils*, though it is by no means remarkable for its volatility. A heat of 212° was not found ſufficient to diſtil it over, when mixed with water in cloſe veſſels. It is this oil which communicates to ale its peculiar ſmell, and in ſome meaſure alſo its flavour. 2. The other ingredient has an intenſely bitter taſte, and a narcotic quality. This ſubſtance is very ſoluble in water. It corrects, to a certain extent, the luſcious ſweet taſte of the ſaccharine matter, and alſo prevents the tendency which the wort would otherwiſe have to get ſour. There is a third ſubſtance which hops give out to water. It has a brown colour, and becomes moiſt when expoſed to the air. Its properties are not remarkable, ſo that we may preſume it has but little effect upon the wort.

Wort retained by Hops.

When the wort is let out of the boiler into the cooler, it is made to paſs through a drainer, that the hops may be retained. Theſe are left upon the drainer full of wort, ſo that a conſiderable loſs is ſuſtained, unleſs means are fallen upon to get this wort ſeparated. The reſult of our trials was, that 100 pounds of hops retained about 1. 13 barrels of wort.

III. The Cooling.

III. The boiled worts, while ſtill hot, are allowed to flow into very large ſhallow ſquare veſſels, called *coolers*, placed in the moſt airy ſituation, in order that the worts may cool as ſpeedily as poſſible. Theſe coolers are of ſuch a ſize that the wort, while in them, is only a few inches deep; and they are ſo placed, that the liquor may be let from one to another, that thus the rate of cooling may be ſtill farther accelerated. The temperature to which the wort is reduced in theſe coolers, depends upon the ſeaſon of the year. In warm weather it is cooled down as much as poſſible; but in winter, which is conſidered as the beſt time for brewing, this would retard the fermentation too much. The uſual temperature in winter is about 52°; but in ſummer, by cooling the wort in the night time, it is brought ſometimes to 46°.

While the wort is in the coolers, it undergoes a conſiderable change in its denſity, the great ſurface of hot wort occaſioning a very copious evaporation. In our trials, the change of bulk averaged very nearly one-fourth of the original quantity; that is to ſay, every 100 gallons of wort in the boiler, when cooled down ſufficiently to be put into the fermenting tun, were reduced to 75 gallons. This reduction is occaſioned not merely by the evaporation, but by the ſeparation of the hops, which greatly increaſed the apparent bulk in the boiler. The cooling alſo cauſes a diminution of about $\frac{1}{25}$th part.

IV. The Fermenting.

IV. From the coolers, the wort is let down into a large deep ſquare or cylindrical veſſel, called the *fermenting tun*, in which it is made to undergo the proceſs of fermentation. This proceſs is brought on by mixing it with *yeaſt*.

Nature of Yeaſt.

Yeaſt is a ſubſtance which collects upon the ſurface of ale during fermentation. At firſt it is yellowiſh, white and frothy; but, when dried, it acquires a good deal of reſemblance to ſome kinds of cheeſe, which it approaches alſo in ſome of its chemical characters. Whether this ſubſtance exiſts previouſly in the infuſion of Malt, or is formed by fermentation, has not been aſcertained by Experiment, though the latter opinion is the more probable of the two.

Phenomena of Fermentation.

Soon after the yeaſt and wort have been mixed in the fermenting back, a white ſcum begins to collect upon the ſurface of the liquor, the temperature riſes, many air bubbles eſcape, and carry along with them a viſcid matter to the top, where it forms a thick froth, conſtantly accumulating. This froth, which is nothing elſe than yeaſt, the Brewer mixes occaſionally with the liquor below, that the progreſs of the whole may be as equal as poſſible. After a longer or ſhorter interval, the inteſtine motion ſubſides, the froth falls down, and the temperature approaches toward that of the atmoſphere. The liquor has now become ſpecifically lighter, and has acquired the taſte and properties of ale. The Brewer draws it off from the fermenting back, and puts it into hogſheads. This is called *cleanſing*. In theſe hogſheads the liquor ferments very ſlowly, throws up a quantity of yeaſt, and lets another portion ſubſide. At laſt it becomes tranſparent, and is then fit for uſe. The temperature of the wort, when let down into the fermenting back, is uſually about 52°; the ſubſequent riſe depends upon the violence of the fermentation, which is in ſome meaſure regulated by the temperature of the room in which the veſſels are placed, but chiefly by the quantity of yeaſt mixed with the wort. If we ſuppoſe the fermenting back properly placed, ſo as to ſecure as nearly as poſſible an equability of external temperature, then the riſe depends upon the yeaſt.

Temperature of the Worts.

Quantity of Yeaſt.

The quantity of yeaſt uſed by Brewers is very ſmall, uſually about one gallon to every three barrels of wort. Hence the fermentation is ſlow and imperfect. The increaſe of temperature during the fermentation of ale, amounts, at an average, to 15°, but is often much leſs. The greateſt riſe in our trials was 27°. This was in ſummer. In one caſe the wort roſe from 44° to 71°, in another from 55° to 82°. When the brewhouſe is too much expoſed, and the wort let down low, the fermentation in ſome caſes produces ſcarcely any increaſe of heat. In one brewing, for inſtance, in which the wort was let down at 52°, the temperature was never obſerved higher than 53°.

When the proceſs is properly conducted, the fermentation uſually acquires its greateſt intenſity about the 5th or 6th day, and by the 9th or 10th it has ſubſided, and the ale is ready for cleanſing. In hot weather, the rate of fermentation is ſo much accelerated, that the ale is put into caſks on the ſixth day, while the increaſe of temperature is at its maximum. In ſome caſes, even fifteen days elapſe before the operation is concluded.

The fermentation is occaſioned by the re-action of the yeaſt on the ſaccharine matter. Carbonic acid is emitted, and a quantity of ardent ſpirits formed. Were the quantity of yeaſt ſufficient, and the fermentation carried as far as poſſible, four-fifths of the ſaccharine matter would diſappear; but this not being the object of the Brewer, ſo little yeaſt is uſed, that a great part of the ſaccharine matter remains. Hence ale is in reality a mixture of fermented and unfermented wort. Accordingly, upon evaporating the ale to dryneſs, a great part of this extract of Malt may be ſtill obtained. The ſpecific gravity of the wort is diminiſhed by the fermentation, in proportion to the quantity of ſaccharine matter decompoſed, and of ardent ſpirits produced. Hence this diminution ſerves as a meaſure of the extent to which the fermentation has been carried. It is known among Brewers by the technical name of *attenuation*. The following Table will ſhew the extent of this change of ſpecific gravity, by fermentation, in ſeveral of the ales brewed under our inſpection.

Reſult of the Fermentation.

TABLE XVI.

MALT BREWED.	Specific Gravity of Wort.	Specific Gravity of Ale.	Difference.	MALT BREWED.	Specific Gravity of Wort.	Specific Gravity of Ale.	Difference.
Norfolk - - - - 1	1. 1060	1. 0264	0. 0796	Edinburgh - - - 1	1. 1116	1. 0310	0. 0796
D° - - - - - -	1. 1030	1. 0275	755	D° - - - - - - -	1. 1206	1. 0351	855
D°. - - - - - -	1. 1070	1. 0310	760	Haddington - - 2	1. 1114	1. 0275	839
Kent - - - - 1	1. 1040	1. 0321	719	D° - - - - - - -	1. 0932	1. 0202	730
D° - - - - - -	1. 1062	1. 0308	754	D° - - - - - - 3	1. 1118	1. 0268	850
D° - - - - - -	1. 1170	1. 0281	889	D° - - - - - - 3	1. 1029	1. 0217	812
Norfolk - - - - 2	1. 0720	1. 0288	432	Lanark Bigg - - 1	1. 0900	1. 0120	780
D° - - - - - -	1. 1066	1. 0308	658	D° - - - - - - -	1. 1160	1. 0294	866
D° - - - - - 3	1. 1070	1. 0249	821	Perth Bigg - - - 1	1. 1110	1. 0342	768
D° - - - - - -	1. 1040	1. 0269	771	D° - - - - - - -	1. 1207	1. 0341	866
Eſſex - - - - 3	1. 1110	1. 0264	846	D° - - - - - - -	1. 1034	1. 0342	692
Haddington - - 1	1. 1046	1. 0218	828	Kirkcudbright Bigg 2	1. 0820	1. 0152	668
D° - - - - - - -	1. 1045	1. 0249	756	D° - - - - - - -	1. 1087	1. 0295	792
Edinburgh - - - 1	1. 1057	1. 0382	675				

Such is a ſhort ſketch of the proceſs of Brewing. From the peculiar nature of ales, and the imperfection of the fermentation to which they are ſubjected, they cannot well be compared together, in order to form an eſtimate of the value of the different Malts from which they have been procured. It is only when they are in the ſtate of worts that this compariſon can be made, and that only as far as regards the quantity of ſolid extract which each yields to water. The following Tables exhibit the reſults of our trial.

Tables of the Brewings.

Theſe Tables conſiſt of eleven columns. The firſt column contains the names of the Grain from which the wort was produced; the ſecond, the weight of that Grain per buſhel; the third, the number of buſhels of Malt uſed at each brewing reſpectively; and the fourth, the weight of this Malt per buſhel. The fifth column contains the quantity of wort, in ale barrels, extracted from the Malt. Sometimes only one wort was taken, water being added till the Malt was exhauſted; ſometimes two and ſometimes three, but in the laſt caſe the third wort was thrown away as uſeleſs. The number of worts procured at each brewing, will be ſeen by inſpecting the fifth column of the Tables, where the number of barrels of each are given. The ſixth column gives the ſpecific gravity of the wort, and the ſeventh its ſtrength, as indicated by the ſaccharometer of Dring and Fage. The eighth gives the total quantity of dry *Extract of Malt*, in lbs. avoirdupois, obtained at each brewing; the ninth, the quantity of dry extract yielded by a buſhel of the Malt employed; the tenth, the quantity of extract which a buſhel of the Raw Grain would have yielded, ſuppoſing that buſhel to have been firſt malted and then brewed. It was calculated by comparing the quantity of Malt obtained from a buſhel of Raw Grain, with the quantity of extract yielded by a buſhel of Malt. The laſt column exhibits the quantity of extract which one pound of Raw Grain would yield, ſuppoſing that pound previouſly malted.

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TABLE XVII.—BREWINGS OF

GRAIN.	Weight per Bushel.	Bushels of Malt used.	Weight of Malt per Bushel.	Wort in Barrels.
ENGLISH.				
Norfolk	50.375	60.0	36.58 2	10.611 7.305
Norfolk	50.375	47.5	36.58	11.131
Norfolk	50.375	55.0	36.58 2	9.176 9.166
Norfolk	50.375	60.0	38.40	14.77
Norfolk	50.375	55.0	38.40 3	7.972 8.166 3.380
Suffolk	50.508	72.0	40.56 3	10.583 8.527 3.550
Kent	49.750	60.0	34.88 3	10.735 7.417 4.465
Kent	49.914	50.0	35.76 5	8.954 7.305 2.727
Kent	49.832	81.875	35.44	11.488 16.222 2.673
Average	50.208	- - -	37.02	- - -
SCOTCH.				
Haddington	52.190	60.	38.06	15.456
Haddington	52.190	72.	39.18	12.603 12.914
Haddington and Berwick	53.094	60.	39.00	14.5
Haddington and Berwick	53.094	54.	39.60	8.000 8.160
Edinburgh	52.164	60.	41.92	11.995 10.722 2.926
Edinburgh	52.164	60.	42.24	10.264 9.528 1.807
Edinburgh	52.164	79.125	41.00	11.324 16.222 2.69
Fife	51.539	72.	38.80	13.055 7.944 4.138
Fife	51.539	72	38.80	13.250 8.500 6.235
Average	52.237	- - -	38.80	- - -
BIGGS.				
Lanark	48.562	60	36.44	15.300
Lanark	48.562	72	36.44	10.900 11.667
Perth	47.854	72	34.44	8.971 9.055 3.470
Perth	48.562	80	37.57	12.094 13.686 12.672
Perth	48.562	60	36.53	9.809 10.361 2.455
Aberdeen	48.562	72	36.03	18.000 9.223 6.236
Aberdeen	48.562	72	36.03	14.000 8.250 6.240
Dumfries	47.000	60	36.81	14.750
Average	48.278	- - -	36.28	- - -

GRAIN, OF FIRST QUALITY.

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Specific Gravity of Worts.	Saccharometer Degree of D. & F.	Total Quantity of Dry Extract.	Solid Extract from a Bushel of Malt in lbs. Avoirdupois.	Solid Extract from a Bushel of Raw Grain.	Solid Extract from a Pound of Raw Grain.
1.106 1.039	- -	1364.89	22.748	24.91	0.4485
1.104	35.5	1071.36	22.588	24 70	0.4843
1.108 1.029	37.5 10.12	1153.23	20.967	22.96	0.4503
- -	31.25	1368.00	22.800	23 84	0.4733
- - - - - -	39.625 10.625 4.5	1220.70	22.190	23.20	0.4406
- - - - - -	45.000 16.25 4.00	1798.46	24.980	25.39	0.5027
1.104 1.033 1.018	34.125	1325.84	22.095	24.58	0.4941
1.106 1.032 1.019	34.5 11.02	1139.52	22.790	24.22	0.4863
1.117 1.049 1.0[illegible]8	40.87 15.25	2037.86	24.889	27.06	0.5431
- - -	- - -	- - -	22 894	24.54	0.4803
1.105	34.25	1510.78	25.199	27.46	0.5262
1.104 1.040	37.125 13.000	1717.74	23.857	24.59	0.4712
- -	34.375	1475.00	24.580	24.73	0.4915
- - - -	42.5 11.0	1328.00	24.600	24.75	0.4919
1.106 1.033 1.011	36.625	1525.93	25.432	25.08	0.4808
1.111 1.044 1.013	39.000	1490.80	24.846	25.51	0.4890
1.121 1.042 1.009	44.000 2.500	1945.58	24.588	25.25	0.4841
1.0	39.5 9.75 2.37	1756.24	24.390	24.39	0.4732
- -	37.75 10.625 2.000	1784.00	24.780	24.78	0.4808
- -	- - -	- - -	24,696	25.17	0.4876
1.090	31.25	1282.16	21.369	22 08	0.4547
1.116 1.040	40.5 14.	1625.63	22.578	23 33	0.4874
1.111 1.057 1.016	39.5 17.75 3.66	1511.01	20.986	21.60	0.4447
1.121 1.0[illegible]8 1.011	42.53 2.18	2011.38	25.142	24.90	0.5128
1.103 1.034 1.011	35.75 11.00	1285.39	21.423	20.87	0.4297
- -	43.375 14.5 2.375	1678.61	23.310	23.14	0.4765
- -	42.00 14.37 2 18	1650.74	22 930	22.76	0.4586
- -	29.75	1299.84	21 660	21.14	0.4498
- -	- -	- - -	22.424	22.47	0.4646

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Report of Experiments on Malt made from Barley and Scotch Bigg.

TABLE XVIII.—BREWINGS OF

GRAIN.	Weight per Buſhel.	Buſhels of Malt uſed.	Weight per Buſhel.	Wort in Barrels.
ENGLISH.				
Norfolk - - - - - - - - - -	50.57	60	38.437	18.135
Norfolk - - - - - - - - - -	50.57	70	38.437	10.878 10.000
Norfolk - - - - - - - - - -	51.	50	37.562	13.694
Norfolk - - - - - - - - - -	51.	52	37.562	7.722 7.83 4.72
Norfolk - - - - - - - - - -	51.	50	37.562	8.79 4.87 8.30
Kent - - - - - - - - - -	49.945	76	36.875	10.527 8.125 4.013
Average - - - - -	50.680	- - -	37.739	- - -
SCOTCH.				
Haddington - - - - - - - - -	52.265	72	37.298	11.378 13 000
Haddington - - - - - - - - -	52.265	60	37.298	15.206
Haddington and Berwick - - - -	50.531	60	38.501	15.00 4.75
Haddington and Berwick - - - -	50.531	64	38.501	10.55 8.22 0.722
Fife - - - - - - - - - - - -	48.508	72	40.036	11.429 7.25 7.25
Average - - - - - -	50.820	- - -	38.327	- - -
BIGGS.				
Kirkcudbright - - - - - - - -	46.875	60	36.40	15.621
Kirkcudbright - - - - - - - -	46.875	72	36.40	9.934 9.611
Ayr - - - - - - - - - - - -	47.937	50	37.83	13.388 4.138
Ayr - - - - - - - - - - - -	47.937	98	37.83	14.5 10.694
Angus - - - - - - - - - - -	47.392	72	38.57	11.111 7.277 10.083
Average - - - - - -	47.403	- - -	37.40	- - -

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GRAIN, OF SECOND QUALITY.

Specific Gravity.	Saccharometer Degrees. D and F.	Total Quantity of dry Extract.	Solid Extract from a Bushel of Malt in lbs. Avoirdupois.	Solid Extract from a Bushel of Raw Grain.	Solid Extract from a Pound of Raw Grain.
1.072	26.0	1234.95	20.582	22.475	0.4444
1.106 1.041	38.5 13.75	1489.92	21.284	23.241	0.4596
- - -	30.625	1181.99	23.640	24.552	0.4814
- - -	39.5 11 625 5.375	1144.13	22.002	22.852	0.4481
- - -	26.375 13.125 1.375	1111.03	22.221	23.078	0.4525
- - -	39.0 16.0 3.75	1624.10	21.370	22.504	0.4506
- - -	- - -	- - -	21.849	23.117	0.4561
1.111 1.032	39.75 10.35	1560.06	21.667	22.359	0.4278
1.093	32.25	1319.84	21.997	22.699	0.4343
- - -	32.75 4.00	1435.15	23.920	24.146	0.4778
- - -	40.25 10.75 5.625	1376.55	21.510	21.831	0.4320
- - -	41.5 20.25 2.[illegible]5	1770.96	24.600	23.137	0.4770
- - -	- - -	- - -	22.739	22.834	0.4498
1.082	29.5	1210.62	20.177	20.428	0.4358
1.109 1.047	38.75 17.25	1441.37	20.019	20.268	0.4324
- - -	28.00 3.75	1062.66	21.253	21.483	0.4481
- - -	39.375 15.	2111.22	21.543	21.560	0.4497
- - -	38.375 2.000	1565.06	21.737	20.552	0.4337
- - -	- - -	- - - -	20.946	20.858	0.4399

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TABLE XIX.—BREWINGS OF

GRAIN. ENGLISH.	Weight per Buſhel	Buſhels of Malt uſed.	Weight of Malt per Buſhel.	Wort in Barrels.
Norfolk	51.937	72.	36.683	10.262 14.528
Norfolk	51.937	72.	36.683	10.484 11.722 2.986
Norfolk	51.625	76.	37.610	14.33 7.61
Norfolk	51.625	76	37.610	14.333 6.250 7.100
Eſſex	47.633	70.	35.125	11.717 12.118 2.085
Eſſex	48.000	72.	35.656	11.472 7.805 10.083
Average	50.459	- - -	36.561	- - -
SCOTCH.				
Haddington	48.969	72	36.816	10.123 8.028 3.441
Haddington	48.969	72	36.816	10.012 8.916 0.995
Berwick	48.854	72	37.312	14.000 5.916 4.750
Average	48.930	- - -	36.980	- - -
BIGGS.				
Kirkcudbright	44.722	67.75	35.031	13.083 6.250 8.472
*Kirkcudbright	44.722	68.00	35.031	13.048 5.125 10.083
Average	44.722	- - -	35.031	- - -

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GRAIN, OF THIRD QUALITY.

Specific Gravity.	Saccharometer Degrees, D. and F.	Total Quantity of Dry Extract.	Extract from a Bushel of Malt Avoirdupois.	Extract from a Bushel of Raw Grain.	Extract from a Pound of Raw Grain.
1. 107 1. 040	38. 25 13. 75	1587. 24	22. 045	23. 457	0. 4516
1. 104 1. 043 1. 012	36. 75 14. 50 2. 25	1519. 95	21. 110	22. 463	0. 4325
- - -	35. 00 11. 50	1676. 85	22. 064	23. 056	0. 4570
- - -	34. 50 17. 625 3. 125	1732. 36	22. 794	23. 820	0. 4614
1. 111 1. 028 1. 010	38. 56 2. 68	1536. 88	21. 955	23. 236	0. 4799
- - -	37. 00 13. 125 2. 375	1540. 30	21. 393	21. 848	0. 4551
- - -	- - -	- - -	21. 893	22. 980	0. 4562
1. 103 1. 047 1. 021	36. 125 16. 250 3. 83	1390. 45	19. 311	19. 617	0. 4006
1. 112 1. 071 1. 011	39. 87 2. 00	1647. 03	23. 014	23. 378	0. 4774
- - -	32. 00 14. 125 2. 75	1490. 51	20. 602	20. 233	0. 4141
- - -	- - -	- - -	20. 976	21. 076	0. 4307
- - -	35. 875 13. 375 1. 5	1481. 78	21. 871	20. 668	0. 4621
- - -	32. 25 1. 25	1306. 86	19. 219	18. 161	0. 4061
- - -	- - -	- - -	20.545	19. 414	0. 4341

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The following Table, which exhibits the average of the preceding three, will enable one to form a pretty correct notion of the comparative value of the different kinds of Malt, as far as the quantity of extract is concerned.

TABLE XX.—AVERAGE OF THE WHOLE BREWINGS.

ENGLISH.	Raw Grain per Buſhel.	Malt per Buſhel.	Extract in Pounds from a Buſhel of Malt.	Extract in Pounds from a Buſhel Raw Grain.	Extra ct from a Pound of Raw Grain.
1ſt Quality - - - -	50.208	37.02	22.894	24.54	0.4803
2d Quality - - - -	50.680	37.74	21.849	23.117	0.4561
3d Quality - - - -	50.459	36.561	21.893	22.980	0.4562
Average - -	50.449	37.107	22.212	23.545	0.4642
SCOTCH.					
1ſt Quality - - - -	52.237	38.80	24.696	25.17	0.4876
2d Quality - - - -	50.820	38.327	21.739	22.834	0.4498
3d Quality - - - -	48.93	36.98	20.976	21.076	0.4307
Average - -	50.662	38.035	22.803	23.026	0.4560
BIGGS.					
1ſt Quality - - - -	48.278	36.28	22.424	22.47	0.4646
2d Quality - - - -	47.403	37.40	20.946	20.858	0.4399
3d Quality - - - -	44.72	35.03	20.545	19.414	0.4341
Average - -	46.80	36.23	21.305	20.914	0.4462

From this Table it appears, that the weight of the Engliſh and Scotch Barley, from which the Malt uſed in Brewing had been procured, was nearly the ſame, but the Bigg was about 8 per cent. lighter. The Malt from the Scotch Barley was heavieſt, and that from the Bigg lighteſt. Were we to eſtimate the value of each, by the quantity of extract yielded by the buſhel of Malt, that value would be as follows:

Engliſh Malt - - - -	97.4
Scotch Barley Malt - -	100
- - Bigg Malt - -	93.4

or the Scotch would be 2½ per cent. better than the Engliſh, and about 6½ per cent. above the Bigg.

Were we to eſtimate the comparative values from the extract yielded by equal weights of each Grain, that value would be as follows:

Engliſh - - - - -	100
Scotch - - - - -	98
Bigg - - - - - -	96

The real comparative value is perhaps beſt found by this laſt method; but according to the preſent mode of levying the Duty by bulk, it cannot be employed.

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ployed. When we eſtimate the value from the quantity of extract yielded by the buſhel of raw Grain, ſuppoſing that buſhel malted, the reſult is as follows:

Engliſh - - - -	100
Scotch - - - -	97. 8
Bigg - - - - -	88. 8

Such are the comparative values of the Engliſh Barley, Scotch Barley, and Bigg, ſubjected to Experiment, provided the quantity of ſolid extract yielded by the Malt to hot water be conſidered as a proper criterion. But, after all that has been ſaid, doubts may be ſtill entertained how far this ſolid extract, though the ſame in weight, is the ſame in quality. There exiſts a method of determining this point with conſiderable preciſion. When the wort is ſubjected to a complete fermentation, the ſaccharine matter diſappears, and a portion of ardent ſpirits comes in its place. Now, if it be found that the ſolid extract from every kind of Grain yields the ſame quantity of ſpirits, it will follow that this extract is always of the ſame quality; but if the weight of extract from different ſpecies of Grain yield different quantities of ſpirits, then it will follow that the extract of Malt differs in its value. To determine this point, it was neceſſary to have recourſe to the operations practiſed by the Diſtiller.

Thomas Thomſon.

IV. DISTILLATION.

THE ſecond mode, by which we propoſed to inveſtigate the relative qualities of the different kinds of Malt, is by the operations of the Diſtillery. By them, the valuable matter of Grain is converted into ardent ſpirits, which, by the aid of the fire and ſtill, are obtained more or leſs diluted with water. The ſtrength and value of theſe ſpirits depend upon the quantity of alcohol which they contain, and which by various methods may be eaſily aſcertained. The quantity of it, therefore, promiſes to afford a ready meaſure of the value of different ſorts of Grain, and has indeed been generally employed for that purpoſe. Unfortunately, alcohol is not an ingredient pre-exiſting in Grain, but the product of a curious inteſtine change, during a ſucceſſion of operations; and its quantity may be influenced, as much by the manner in which the proceſs is conducted, as by the quality of the Grain itſelf.

In attempting to determine the relative values of the Malts made from Barley and Bigg, from the quantity of ſpirit which they reſpectively yield, it, at firſt, appeared reaſonable that we ſhould only employ in our operations pure Malt, and the more ſo, as the Experiments, of which an account had been preſented to the Committee of the Houſe of Commons, were inſtituted on Grain in this condition. We were, however, determined, by the following conſiderations, to adopt, in part, a different plan. 1ſt. It is the general opinion of Diſtillers, that raw Grain produces more ſpirit, than the ſame Grain when malted. This opinion, if well founded, would indicate the loſs of ſomething capable of affording ſpirit, during malting. 2nd. The loſs of weight in malting varies according to the manner in which the proceſs is managed. Hence we concluded, that the produce of Malt, in ſpirits, might vary according to the previous method of malting, independently of the quality of the Grain itſelf. Raw Grain is free from this ſource of variation; and therefore, we hoped to ſucceed beſt, in our attempts to diſcover the relative values, by uſing a large proportion of it: aware that the inferences from the trials made on raw Grain, could only be applied to Malt, provided the general opinion, that the different ſorts of Grain bear the ſame proportion to each other, in the quantity of ſpirit they afford, as the Malts made from them, be well founded.

Though Diſtillers frequently employ a proportion of malted Grain, not greater than $\frac{1}{5}$th, or even $\frac{1}{10}$th, we preferred the proportion of two parts of raw Grain to one of the ſame Grain malted. Two ſuites of Experiments were made with theſe proportions; a third conſiſted of pure Malt.

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In all theſe Experiments, the operations were on a ſcale equal in extent to what is uſual in the ordinary way of buſineſs, and were managed as nearly in the ſame manner as was conſiſtent with preciſion. At one of the Breweries buildings for a Still-houſe were erected, and the whole became a very commodious Diſtillery. To ſuperintend and direct the operations, a ſkilful Diſtiller was procured, who had long been engaged in conducting the practical part of extenſive eſtabliſhments, and was converſant in all matters relative to the buſineſs of Diſtillation. As the utenſils were found to be of dimenſions adapted to maſhing ſixty buſhels, this quantity was uſed in all the trials mentioned in the ſequel.

The firſt ſuite conſiſted of ſix ſucceſſive brewings with each quality of Grain. The ſecond, of one brewing, with each quality of Grain. The Malt ſuite was conducted in the ſame manner as the ſecond.

The proceſs of the Diſtiller is complicated. It may be divided into four parts. Theſe are—

I. Preparation and grinding.
II. Brewing.
III. Fermenting, and
IV. Diſtilling.

We ſhall deſcribe the manner in which each of theſe operations was conducted in our Experiments, and add ſome general conſiderations reſpecting them.

I. Preparation, and Grinding.

As the Grain for Diſtillation was not all of the ſame degree of cleanneſs, and as its worthleſs parts are not removed by ſteeping, as in the brewery, the whole of it was paſſed through the fanners; not to dreſs it to a high pitch, but to bring it all, as nearly as poſſible, to a ſtate of equality in this reſpect. The light Grains varied from $\frac{1}{100}$th, to $\frac{1}{200}$th part of the weight of the whole.

The Grain for each brewing was meaſured and weighed. It was then ground to a fine meal, in conformity to the opinion of Diſtillers, that, in that ſtate, it yields beſt in the maſh tun. The loſs unavoidable in this operation, was aſcertained by weighing the meal: At an average, it amounted to $\frac{1}{100}$th part. The calculations given afterwards, founded upon the weight of the Grain, always bear relation to the quantity of the meal actually thrown into the maſh tun.

The Malt, having been duly dreſſed and meaſured at the period of its preparation, was taken according to that original meaſurement, even though, from regaining part of its moiſture, it had acquired ſome additional bulk. The quantity neceſſary for each Experiment, was weighed out when wanted, and ground in a mill on the ſpot. Inſtead of loſing weight, as the raw Grain did, it, in general, gained a little. This increaſe was owing to the abſorption of humidity, and, conſequently, was moſt remarkable, when the Malt had been highly dried in the kiln, and when it was ground in moiſt weather. It amounted, at an average, to about $\frac{3}{1000}$th part.

II. The Brewing.

Brewing is the ſecond of the Diſtillery-operations. It comprehends the extraction of the ſoluble parts of the Grain by water, and the formation of the ſolution, which, as in the brewing of ale, is called *wort*. Having already deſcribed, in a general way, this part of the proceſs, we ſhall only mention thoſe accommodations of it which our Experiments in the Diſtillery required. The farinaceous ſubſtance of Barley is of much leſs eaſy ſolution than the ſaccharine one of Malt, and demands a nicer adjuſtment of the temperature of the water, and greater mechanical agitation, to effect it.

Firſt Maſh.

In the ſuites of Experiments with mixtures of raw Grain and Malt, the quantity of water introduced into the maſh tun, was generally 730 gallons* of the temperature 150°. This heat is lower than what is uſed in brewing

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* Whenever the term *gallon* is uſed in deſcribing the proceſs in the Diſtillery, *a wine gallon* is meant, unleſs the contrary be mentioned.

ale;

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ale; becauſe the danger of the *ſetting*, or conglutination of the meal into denſe impenetrable maſſes, from a more elevated temperature, is conſiderably greater. On the other hand, to promote the ſolution, the agitation was more aſſiduouſly employed, and for a period not leſs than an hour and a half. During this maſhing, about 500 gallons of water, at a temperature from 180° to 190°, were uſually added. Two hours were allowed for the *infuſion*, or rather for the ſubſidence of the Grain, and the ſeparation of the clear liquor, which does not flow into the under-back through a hole in the bottom of the maſh tun, but is let off from above, by apertures in a large tube, or trunk, which penetrates the bottom, and riſes to the top. As the liquor flowed out, its temperature was, very uniformly, within two or three degrees of 150°.

Diſtillers, dreading the diſpoſition of worts to acquire a degree of acidity, if permitted to continue any length of time at an elevated temperature, do not ſuffer them to remain in the under-back. In imitation of their practice, the wort was immediately pumped from the under-back to the coolers, where, from the ſmall depth and extended ſurface, it cooled with ſufficient rapidity, without the aſſiſtance of conſtant agitation, which is employed in Diſtilleries where expedition is ſo much wanted. From the coolers, the worts are conveyed into the veſſel in which they are to be fermented.

The temperature at which the worts are "*let down*," is, in general, higher, than in Breweries. It is regulated in ſome meaſure by that of the air. In cold weather, the firſt worts were permitted to flow into the fermenting tun at 70°. During the warmth of ſummer, they were cooled as far as the air would admit. The worts being conveyed to the coolers, as ſoon almoſt as they reached the under-back, their quantity and ſtrength could only be determined by the gauge of the coolers, and by an examination of them when ready for the fermenting tun.

Second and Third Maſhes.

For the ſecond maſh, commonly 500 gallons of water, at about 180°, were employed. The *ſtirring* was renewed for half an hour, and about one hour and a half was allowed for the infuſion and ſubſidence. This maſh was treated preciſely in the ſame manner as the preceding. After the ſecond worts had run from the maſh tun, a third maſhing was practiſed with about 900 gallons of water, at nearly the boiling temperature.—On moſt occaſions, three maſhings were found ſufficient to extract all the valuable matter of the Grain; but, ſometimes, four were found neceſſary. It is of conſequence to uſe any ample quantity of water. It anſwers two purpoſes:—It moſt thoroughly extracts all the ſoluble matter from the Grain, and it forms worts of a moderate degree of ſtrength, which is very favourable to the proceſs of fermentation. In general, the quantity of wort drawn in our Experiments from each buſhel, amounted to 22 or 23 gallons; it was never leſs than 20, a larger quantity than what Diſtillers draw; the Duty on the waſh, and on the capacity of the ſtill, limits them. In the courſe of our Experiments, we had occaſion to remark, that a greater "length" than now indicated did not prove beneficial.

As the worts from the third and fourth maſhing are often weak, it is uſual to employ them in the firſt and ſecond maſhes of the ſubſequent day. In the firſt ſuite of experiments, in which, for ſix ſucceſſive days, we operated upon Grain of the ſame denomination, this plan was followed. In the other two ſuites, the weak worts of the third and fourth maſhes were boiled during night to the proper ſtrength, and mixed with the others.

Owing, perhaps, to the nature of the amylaceous matter, which conſtitutes ſo large a proportion of the ſoluble ſubſtance of raw Grain, and to its being ſo much leſs ſoluble in cold water than in hot, the worts, while on the coolers, depoſit a conſiderable portion of flocculent matter. Whether this matter contributes to the ſtrength of the worts, and adds to the quantity of ſpirit, as Diſtillers believe, is a queſtion not eaſily determined; but it was thought requiſite to follow the uſual practice, and to ſweep the whole of it into the fermenting tun.

The journals of our operations, now before the Honourable Board (of which we ſhall ſubjoin a ſpecimen) include a variety of other obſervations that were made during this ſtage of the proceſs; ſuch as the gauges of the maſh tun, before and after each addition of Grain or of Liquor; the change of temperature

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ariſing from ſuch addition, and from the maſhing or agitation; the time which the worts required to flow, and to cool; the gauges of the coolers; and the ſtrength of the worts, at different periods.—Theſe obſervations were made, that we might have a faithful record of every occurrence, and alſo, that the number of them might keep our people on the alert, and furniſh a multitude of checks to prevent or detect any miſtake or overſight.

III. Fermentation.

The third part of the proceſs is the Fermentation of the Worts. It is, perhaps, the moſt important of any, as in the courſe of it, the object of the whole operation is produced. The change is truly remarkable; by which the ſolid, mild, nutritious matter of Grain, is converted into the ſubtile, intoxicating fluid of alcohol. The whole is the conſequence of a new arrangement of the conſtituent elements, induced by a play of chemical attractions, in which the ſolid matter is reſolved into ſpirit and the ſuffocating elaſtic fluid of carbonic acid.

The Diſtiller carries the fermentation of the worts much farther than the Brewer. Indeed, he encourages it to the utmoſt, that the largeſt poſſible quantity of extract may contribute to the production of ſpirit. The worts of themſelves would ferment, but imperfectly. Yeaſt therefore is employed to accelerate and promote the fermentation in much larger quantity than in the manufacture of ale. All the circumſtances, formerly mentioned, of riſe of temperature, intumeſcence, and agitation, occur in a more remarkable degree. The carbonic acid is often generated ſo profuſely as to cauſe a commotion reſembling gentle boiling, and flowing over the ſides of the tun, marks its courſe by extinguiſhing candles, or proving deſtructive to ſmall animals approaching it. The fermentation generally reached its greateſt activity in three or four days, remained a ſhort time in that ſtate, and then gradually abated. Its progreſs is marked by important changes. The thick, adheſive wort is progreſſively transformed into a thin fluid of a ſharp acidulous taſte, called *waſh*, and at the ſame time, its ſpecific gravity gradually diminiſhes, till at length it becomes nearly equal to that of water, and in ſome caſes leſs. This diminution of ſpecific gravity, termed *attenuation*, is the conſequence of the transformation of the extract into alcohol, and bears a conſtant relation to the progreſs of the fermentation.

Circumſtances influencing Fermentation.

Though this proceſs is by no means under ſuch perfect controul, as to enable the operator to enſure the complete attenuation, yet it is influenced powerfully by a number of circumſtances, which may be in ſome meaſure regulated at pleaſure. Theſe are, 1. The nature and quality of the extract drawn from the Grain. 2. The ſtrength of the Wort. 3. The Temperature. 4. The quantity and quality of the Yeaſt. By proper attention to them, the intelligent Diſtiller regulates, to a certain degree, the fermentation, and in their accommodation and due adjuſtment, diſplays his ſuperior ſkill. We ſhall briefly ſtate the manner in which theſe circumſtances were managed.

1. Quality of extract.

1. The extract from raw Grain differs from that yielded by Malt in many reſpects; among others, in having leſs diſpoſition to ferment. Hence, the fermentation takes place with greater or leſs readineſs, according to the proportion of Malt uſed in the *griſt*. We have already ſtated, that we uſed both pure Malt, and a mixture of two parts of Grain and one of Malt.

It is a point not yet decided, but which we ſhall conſider afterwards, whether the extract from the two ſpecies of Grain, Barley, and Bigg, and from the different varieties of the ſame ſpecies, is at all times equally ſuſceptible of thorough fermentation.

2. Strength of Wort.

2. Fermentation is very much influenced by the ſtrength of the worts, or the quantity of water in which the extract is diſſolved. A certain quantity of this fluid is at all times neceſſary. Though ſaccharine matter is peculiarly prone to fermentation, yet ſugar, or the ſaccharine extract of Malt, in a dry ſtate, may be kept for ever, and even ſyrup may be uſed as a preſervative of vegetable juices againſt fermentation. A due dilution, by ſeparating and dividing the particles, favours the play of thoſe chemical attractions, by which the interchange of principles and the production of ſpirit are accompliſhed.

In our Experiments, as has been already mentioned, the quantity of worts, drawn from one buſhel of the mixture of Grain and Malt, was generally from 20 to 23 gallons, and in the Malt ſeries, it was from 23 to 25. But the quan-

tity

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tity of worts from a given bulk of Grain ought to vary with the quality of the Grain, and ſhould be regulated by their ſpecific gravity. Daily experience has led Diſtillers to believe, that great ſtrength of worts is unfavourable to fermentation; while, from a very fair inſtance of comparative trial, we conclude, that a greater degree of dilution than that employed in our Experiments is by no means neceſſary or ſerviceable. In our trials, the worts, at an average, had a ſpecific gravity of nearly 1053, compared to water called 1000, which indicates the preſence of fifty pounds of extract in each ale barrel of 43.904 wine gallons. In Diſtilleries, the worts uſually contain from ſeventy to eighty pounds per barrel.

3. Temperature.

3. By no circumſtance is the proceſs of fermentation more affected than by that of temperature, and it is one which, at leaſt in the commencement of the operation, is perfectly in the power of the Diſtiller to regulate. The conſtituent particles of the extract, when divided by water, are ready and eager to aſſume their new arrangement; but their movements depend entirely upon the temperature. Depreſs the heat conſiderably below 50°, and all remains at reſt; elevate it beyond that point, and the different arranging attractions commence the fermentation, and their activity keeps pace with the degree to which the temperature is raiſed. As it is not the fermentation which advances at firſt with the greateſt rapidity, that ultimately makes the greateſt progreſs; worts are let down into the fermenting tuns at a moderate warmth; the preciſe temperature being regulated, in a conſiderable degree, by the ſtate of the weather. When the air was of a medium temperature, the firſt worts were generally run from the coolers at 66° or 68°, and the ſecond at 58° or 60°. During the continuance of the warm weather, the firſt worts were nearly of the ſame heat, but the ſecond were cooled, if poſſible, to 50°; and in the colder part of the ſeaſon, the firſt were generally at 70° or 72°. When all the worts were mixed in the tun, their mean temperature was 62° to 64°.

As ſoon as the fermentation commences, the worts begin to grow warm; and the more rapid and violent the fermentation, ſo much the quicker and greater is the riſe of temperature. The diſengagement of heat which cauſes the riſe, is the conſequence of the new arrangement of the component parts of the extract, and, in particular, of the intimate union of thoſe principles which form the carbonic acid, and it keeps pace with theſe inteſtine changes. The increaſed warmth, thus produced, re-acts on the power by which it is cauſed, and eſſentially contributes to promote the fermentation; becauſe at an elevated temperature, the chemical attractions, that occaſion the whole movement, act with more energy. Were it poſſible to meaſure by a thermometer the whole heat evolved, this inſtrument would be an excellent index of the progreſs and degree of the fermentation. The thermometer, however, only marks the increaſe of temperature which the worts acquire, and gives no information of the heat communicated to the air, and contiguous bodies.

Though the heat diſengaged during the fermentation on different occaſions ſhould be equal, the temperature of the worts would vary very much according to that of the air. Thus, in warm weather, the maximum temperature was 8° or 10° higher than in the beginning of winter.

Still, however, the indications of the thermometer, when due attention is given to the ſtate of the weather, prove of great ſervice to the Diſtiller, as by them he judges of the propriety of promoting or checking the proceſs. In our Experiments, the riſe of temperature was not uniform in its progreſs, nor equal in its amount. It varied in both theſe points, according to the ſeaſon, the temperature at letting down, and the quantity of yeaſt added. Of twenty Brewings of the mixture of Grain and Malt, in the months of Auguſt and September, when the weather was warm, the average maximum temperature, during the fermentation, was 83½°; the higheſt being 86° and the loweſt 77°. The temperature roſe to the maximum at different periods. It was obſerved, at the concluſion of the 2d day, in 1 inſtance,
3d D° in 8 d°
4th D° in 7 d°
5th D° in 3 d°
6th D° in 1 d°.

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Of ſix Brewings of pure Malt, in the month of October, the average maximum was 81.8°, the higheſt being 84°. and the loweſt 77°. Of theſe, 2 were obſerved at the end of the ſecond day, and 4 at the end of the third. In the ſame month, the average maximum of ſix Brewings from the mixed griſt, was ſo low as 77½°. The higheſt did not exceed 80° and the loweſt 76°, and of them, 1 was obſerved before the end of the 3d day,
3 - - - - - - - 4th
1 - - - - - - - 5th
1 - - - - - - - 6th

Among theſe, the fermentation of the Malt worts attained its height, in the ſhorteſt period. The difference obſerved between the progreſs of the worts of the mixed griſt, at the different ſeaſons, indicates the influence of the temperature of the air. From the period of greateſt elevation the temperature gradually declined, and pretty regularly, to the termination. The increaſe of temperature and the attenuation of the worts bore a certain, but not a conſtant, ratio to each other. When the heat roſe quickly, in the ſame ſpace of time, the greateſt attenuation took place. But the total attenuation was not proportional either to the rapidity or the amount of the riſe. Thus the attenuations of the Brewings, in the cold weather of October, were as complete as thoſe of Auguſt, though the heat roſe neither ſo quickly nor ſo high. When in cold weather, and with a tardy fermentation, the maximum temperature is conſiderably below that of a warmer ſeaſon, it is not fair to conclude that leſs heat is generated. Being more ſlowly diſengaged, and more quickly communicated to the ſurrounding air, it conſequently affects the temperature of the wort leſs.

On ſtriking the average of many Brewings, it appeared, that by the time the temperature had reached its maximum, $\frac{9}{10}$th of the total attenuation was accompliſhed.

4. Yeaſt.

4. The next circumſtance by which the fermentation is regulated, is the application of the yeaſt. From the remarkable power it poſſeſſes in inducing and encouraging the fermentation, the quantity, the quality, and the period of adminiſtring this ſubſtance, have a very powerful influence over the proceſs.

Yeaſt is a very heterogeneous matter, and on different occaſions preſents very different qualities. Diſtillers procure the yeaſt from the porter breweries, which is obtained in two ways. The one of theſe conſiſts in allowing the tuns to work over or *throw* their yeaſt. Such yeaſt is much eſteemed. The other, and more common way, is to collect the ſlimy head and the feculent depoſit, which are mixed at the bottom of the tun, when the clear porter is drawn off. In whatever manner the yeaſt is procured, its qualities and powers ſuffer an alteration by keeping. It is uſed, however, both in its recent condition, and after it has become ſtale. Diſtillers, dreading leſt the fermentation ſhould proceed with too much rapidity and vehemence, do not mix the whole quantity of yeaſt, which the brewing may require, at one time, but add it in different portions, employing at firſt the freſh, and afterwards the ſtale.

In this part of our operations, it is ſcarcely neceſſary for us to ſay, that we confided totally in the judgment and ſkill of our Diſtiller. His conſtant practice was to mix, with the firſt worts, nine gallons of freſh yeaſt the inſtant they flowed into the fermenting tun. The ſubſequent additions were made on the ſucceeding days. The ſtale yeaſt was imported from the London Porter Breweries. The quantity of it employed, on an average, amounted to 22 gallons for each Brewing (or about one gallon to 55 gallons wort) which were all mixed in the courſe of the ſecond, third, and fourth days; the larger portion being added commonly on the 2d or 3d of theſe days. The general notion of Diſtillers, that ſtale yeaſt is beſt calculated for urging on the fermentation when fairly ſet a-going, does not ſeem to be eſtabliſhed by accurate Experiments; and we apprehend that its taſte, which often borders on the offenſive, muſt materially affect the flavour and quality of the ſpirits. In the ſuite of Experiments with Malt, freſh yeaſt alone was uſed.

Size of Tuns.

Beſide theſe four circumſtances, which principally affect the fermentation, there are ſome others which deſerve to be mentioned. Diſtillers ferment the ſame quantity of worts in tuns of very different ſizes. Some uſe large veſſels, to

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to afford full ſpace for the intumeſcence; others have them of ſmaller capacity; and prevent the overflow, by inſerting an open tube into the cover of the tun, through which the ſpume may aſcend to a reſervoir, and again return as ſoon as the violence of "working" has abated. The tuns for our operations had a capacity of 1800 gallons, and were ſufficiently large for the worts, in general amounting to 1200 or 1400 gallons, to work without running over. On ſome occaſions, indeed, this would have happened, had it not been prevented by frequently beating down the head.

Effects of cloſe Tuns.

Diſtillers generally prefer the method of fermenting in covered veſſels, and therefore it was adopted in theſe Experiments. In perfectly cloſe veſſels, the fermentation cannot be conducted; for though ſpirituous fermentation is altogether independent of any intercourſe with the air, it is indiſpenſably neceſſary that the elaſtic fluid, the carbonic acid, which is generated in great abundance, ſhould have an opportunity of eſcaping. Were it to be confined, it would ſoon, by its accumulation, acquire an expanſive force ſufficient to burſt the ſtrongeſt barriers. It is, however, of advantage to render its eſcape ſomewhat difficult, as this reſtraint diminiſhes the quantity of ſpirituous matter, which it never fails to carry along with it, and which imparts the peculiarly grateful pungency that the carbonic acid, from fermenting worts, poſſeſſes.

The tuns are not however, in general ſhut till the fermentation has made ſome progreſs. With us, they were commonly covered cloſely on the fourth day. In the later ſtages, when leſs elaſtic fluid is produced, it is of decided advantage to preclude the contact of air as much as poſſible, for, at this period, the wort or fermenting fluid, is apt to run into acidity.

The air of the atmoſphere has very great power in accelerating the change; its purer portion, which is well named the principle of acidity, is abſorbed, and eſſentially contributes to the formation of the acid. Hence, by excluding the acceſs of the air, the tendency to acidity is conſiderably repreſſed. With every precaution however, when the fermentation has run its full courſe, a certain portion of acid is formed.

When the temperature of the waſh falls to that of the air, and all viſible commotion ceaſes, the fermentation is nearly at an end. The attenuation however, ſtill, for a while, goes on; but when it ſtops, the ſpirituous fermentation is concluded. Before this happens, the ſlimy head generally falls, and leaves the waſh a clear thin fluid.

Worts, from a mixture of raw Grain and Malt, ferment with leſs rapidity than thoſe from Malt alone. The ſtationary ſtate of denſity, in all caſes, marked the completion of the proceſs, and ſhewed that the waſh was ready for the ſtill. This happened on the tenth or eleventh day, with the worts, from a mixture of raw Grain and Malt, and, at the lateſt, on the eighth or ninth, with the others. It is improper to permit the waſh to remain any conſiderable length of time after the ſaccharometer has become ſtationary, as it begins to undergo a further change, by which its ſpecific gravity increaſes again. Though the converſion of the ſolid, bland, farinaceous, or ſaccharine ſubſtance, into the intoxicating volatile fluid of alcohol, is a very remarkable circumſtance, it would be foreign to this Report to attempt to trace the nature and cauſe of each chemical change by which the converſion is effected. We ſhall therefore, inſtead of indulging in any ſpeculation upon this ſubject, confine ourſelves to ſome obſervations reſpecting points of conſiderable practical utility.

Attenuation: meaning of term.

1. The diminution of denſity, or ſpecific gravity, is one of the moſt ſtriking effects of fermentation. This change is uſually called "attenuation;" and if the term were implied merely as an abbreviated expreſſion for the decreaſe of ſpecific gravity, it would be ſufficiently proper; but by Diſtillers, it is more generally uſed to denote the reduction in the quantity of extract effected by fermentation.

The Diſtiller judges of this reduction by the ſaccharometer. When, for example, a wort, having a gravity by this inſtrument equal to eighty pounds of extract in each barrel, is converted into waſh, and exhibits a gravity correſponding, by the ſcale, to four pounds per barrel, he imagines that the other ſeventy-ſix pounds have been attenuated. In this concluſion he errs greatly: he is deceived

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deceived by the inſtrument, for ſuch a waſh may contain nearly four times as many pounds as are indicated by it. The ſaccharometer, it is obvious therefore, does not mark the quantity of extract that diſappears; and the term attenuation, as employed by Diſtillers in general, is, on this account, inaccurate. We ſhall therefore always uſe it in the firſt acceptation, that is, as a convenient and ſhort way of expreſſing the decreaſe of ſpecific gravity.

How aſcertained.

The common ſaccharometers do not with any greater degree of preciſion denote the *attenuation*, taken in its proper ſenſe; becauſe all of them are conſtructed upon the principle, that the degrees of their ſcale ſhould correſpond with, and indicate a certain quantity of extract contained in a given bulk of wort, while none of them exhibit the real ſpecific gravity of the fluid; and in no caſe has the relation between their degrees, and the real ſpecific gravity, been determined. Hence, theſe inſtruments, though they manifeſt a progreſſive change in the denſity of worts, and in ſo far are very valuable, do not indicate the true ſpecific gravity, nor the change of it. To remedy their imperfections, one of our number, Dr. Thomſon, has conſtructed a ſaccharometer which exhibits the real ſpecific gravities, as hydrometers do. In it the zero, or beginning of the ſcale, repreſents the ſpecific gravity of diſtilled water, which is called one thouſand, and each degree is equivalent to $\frac{1}{1000}$th part. By the aſſiſtance of a ſliding rule, the real ſpecific gravity may at once be tranſlated into the language of the Diſtillery, and it then denotes the quantity of extract per barrel, and alſo the proportion of extract per cent. in any wort. This inſtrument, therefore, indicates the real ſpecific gravity, and truly ſhews the attenuations; on this account, the language of it is uſed in deſcribing the Diſtillery Experiments.

Cauſe double.

2. The change of ſpecific gravity proceeds from two cauſes of a very contrary nature, which conſpire, however, to produce the ſame effect. The one is the actual decompoſition, and conſequent decreaſe of the ſolid matter of the extract, and the other the ſubſtitution of the very light ſubſtance of alcohol. Theſe always keep pace with each other, and by their joint effect increaſe the ultimate attenuation. Whenever any portion of ſpirit is generated, in conſequence of its levity, it counteracts the gravity of the remaining unchanged extract, and cauſes the fermenting wort, or waſh, to appear leſs denſe than from the quantity of extract it otherwiſe would do. This circumſtance is the ſource of the miſtake above-mentioned, into which Diſtillers often fall, and renders the indication of the ſaccharometers, reſpecting the quantity of extract remaining in waſh, and the concluſions of Diſtillers concerning the quantity of it conſumed, altogether erroneous. One example will illuſtrate this ſufficiently: a ſtrong wort, after fermentation, had a ſpecific gravity of 1004. 5, which indicates 3. 6 pounds of extract in each barrel; but upon trial, the actual quantity of extract remaining, amounted to 15. 5 pounds. The preſence of alcohol, therefore, counteracted the gravitating effect of 11. 9 pounds in each barrel. Now the ſame thing muſt occur, to a greater or leſs degree, in all waſh.

The ſpecific gravity of this fluid is the balance of the oppoſite effects of the heavy extract, and of the lighter ſpirit, and, conſequently, gives no information reſpecting the actual quantity of either ſubſtance. It is not an uncommon thing for worts to be attenuated to zero, that is, to the ſpecific gravity of water, or even below it; ſtill they contain ſolid extract, and the quantity of it may be either large or ſmall, according to the original ſtrength of the wort; but this quantity is accompanied with ſuch a proportion of ſpirit, as juſt counteracts its gravity.

Though the ſpecific gravity of waſh, by itſelf, gives little information reſpecting its contents, yet, when conſidered in connexion with that of the wort, it communicates a great deal, as will immediately appear.

If it be wiſhed to appreciate the ſhare of the attenuation which is due to the operation of each of theſe cauſes, it may be done in the following manner: Firſt, obſerve the number of degrees of attenuation which the wort has undergone, then take a given meaſure of the waſh, note its gravity, and diſſipate all the ſpirit by boiling; laſtly, add to the remaining fluid as much pure water as makes up the original quantity. The gravity which the liquor now has, compared with that of the original unfermented worts, ſhews the amount of the attenuation occaſioned by the loſs of extract, and compared with that of the waſh,

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waſh, ſhews what is owing to the ſpirit. Thus, for example; ſuppoſe the gravity of the wort to be 1080, and of the waſh 1004, and that the gravity of the latter, after the ſpirit has been diſſipated, and its place ſupplied by an equal bulk of pure water, is 1019; then the difference between 1004, the ſpecific gravity of the waſh, and 1080 the gravity of the wort, is the total or apparent attenuation of 76 degrees; the difference between 1,019, the ſpecific gravity of the boiled waſh, and 1080, or 61°, is the ſhare of the attenuation ariſing from the loſs of extract, which we call the *real* attenuation; and the difference between 1019 and 1004, the gravities of the boiled and unboiled waſh, or 15°, is that due to the operation of the ſpirit.

In ſeveral trials we collected the ſpirit by diſtillation, and aſcertained the quantity of extract remaining by the ſaccharometer, or by evaporation, and ſo determined the quantity of alcohol that counterbalances a given weight of extract in its effect on the ſpecific gravity of wort. From the average of a number of them, which accorded very nearly with one another, it appeared that one pound avoirdupois of extract is counterbalanced in its effect upon the gravity of waſh, by 3992 of a wine gallon of ſtandard alcohol .825. It was with conſiderable ſatisfaction that we found this deduction perfectly correct; for on adding dry extract and alcohol to water in the proportions now aſſigned, the ſpecific gravity of the water was not effected by $\frac{1}{3000}$th part. 3. As attenuation ariſes from the converſion of extract, by fermentation, into ſpirit, the apparent attenuation ſhould be proportional to the degree and ſucceſs of the fermentation, and may be employed as a teſt of the quantity of ſpirit produced. The term *apparent* attenuation, we may once for all obſerve, is uſed to expreſs the number of degrees of change which the fermenting fluid undergoes; as when a wort of ſpecific gravity 1050 yields a waſh of 1005, the difference, or 45°, is the *apparent* attenuation. It has no reference to the ſpecific gravity which the waſh at the termination of the fermentation may poſſeſs, and which may be diſtinguiſhed by the name of *acquired* attenuation. Thus, if two portions of wort, one having a ſpecific gravity of 1034, and the other of 1064, be fermented, the waſh of both may have the ſame ſpecific gravity, the ſame *acquired* attenuation, ſay of 1004; but the *apparent* attenuation of the ſecond is double that of the firſt: or the *apparent* attenuation in a waſh having the *acquired* attenuation of 1010, the produce of a wort at 1060, is greater than the *apparent* attenuation in one of 1005, from a wort at 1050:—In the one caſe, the *apparent* attenuation amounts to 50°, in the other, to 45°.

Attenuation the meaſure of fermentation.

Proportion between attenuation and quality of ſpirit.

The quantity of ſpirit produced by fermentation, is conceived to bear an exact proportion to the apparent attenuation, ſo that the latter may be uſed as an index of the former; that waſh containing moſt ſpirit, which has undergone the greateſt *apparent* attenuation. It appeared an object of much importance, as well as curioſity, to diſcover the exact quantity of ſpirit generated during an apparent attenuation of any given amount. Such knowledge would enable the Diſtiller, or Revenue Officer, to foretel the produce of ſpirit which waſh ſhould yield, and ſo to detect careleſsneſs or fraud. At different periods of this inveſtigation, we have attended to this object, and found the moſt favourable opportunity of doing ſo during the Experiments in the Brewery; as we could determine at one inſtant both the ſtrength and quantity of the worts, a thing which could not be done in the Diſtillery, at leaſt with equal preciſion, for the reaſons which are aſſigned in another place.

When we commenced our Experiments in Brewing, we had only the ſaccharometers in common uſe, and principally employed that of Dring and Fage, London, correſponding with the original inſtrument of Richardſon. It was the quantity of alcohol, formed during the attenuation of a degree upon the ſcale of this inſtrument, which was examined. The reſult of various trials, which differed very little from one another, as the tabular view of them ſubjoined teſtifies, is, that, when an ale barrel of wort from Malt, is attenuated, one degree of this ſaccharometer, there is produced .17869 of a wine gallon of alcohol of the ſtandard ſtrength of .825. When, by calculation, this is transferred into the common meaſures and language of the Diſtillery, it ſhews that 100 wine gallons of wort, when attenuated one degree of the inſtrument now mentioned, contains .39556 of a wine gallon of alcohol .825, or .64519 of a gallon of proof ſpirit of ſpecific gravity .920. The inſtrument above alluded

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to was intended to indicate, by the conſtruction of its ſcale, the preſence of one pound of extract in each ale barrel of wort for each degree. But here a great miſtake has been committed; for each degree, as before-mentioned, is equivalent to 2.55 libs.

By trial we find, to transfer the indication by this inſtrument into the language of ſpecific gravity, it may be done, with ſufficient accuracy, by multiplying the degrees under 12 by 3, and thoſe above 12, by 2.75.

In examining the ſhare which the two cauſes producing attenuation, had in occaſioning that effect, a curious coincidence occurred which it may be worth while to mention, as it may enable one to form a pretty correct notion of the quantity of ſpirit in any ale or waſh, even though one be ignorant of the original ſtrength of the worts. The coincidence is this, every degree of attenuation according to the ſaccharometer of Dring and Fage, occaſioned by the preſence of ſpirit, and diſcovered by the ſimple Experiment of expelling the ſpirit as before deſcribed, indicates the preſence of one wine gallon, more exactly indeed of 1.028 gallons, of ſtandard alcohol, in each ale barrel, which contains 43.904 wine gallons.

Progreſs of attenuation.

Having mentioned the importance of attenuation, it need ſcarcely be remarked, that particular attention was given in our Experiments to this remarkable change. The original gravity of the worts, as nearly as could poſſibly be aſcertained; the apparent attenuations of every day; and the acquired attenuations of the waſh, were carefully noted and recorded. The attenuation did not proceed in any regular manner, it kept pace with the fermentation, and, like it, advanced more rapidly at one time than at another. Within the firſt twenty-four hours after the mixture of the yeaſt, it ſeldom exceeded two or three degrees. In the ſecond, third, and fourth periods of the ſame duration, the greateſt change took place; and by the time that the temperature had reached its maximum, nine-tenths of the whole apparent attenuation was accompliſhed: and, as has already been obſerved, this took place in the worts from the mixed griſt, moſt frequently, before the cloſe of the fourth day in warm weather, and before the cloſe of the fifth day in cold, and in the worts from pure Malt, before the end of the third.

When the temperature of the worts began to decline, i. e. from the fourth or fifth day, the attenuation proceeded ſlowly, but advanced, even after all other marks of fermentation were over, to the 11th or 12th, The greateſt attenuation that happened in the ſpace of one day, was 35°; but it rarely amounted to 30°, and ſeldom exceeded 25°. The *apparent* attenuations varied conſiderably, both according to the original ſtrength of the wort and the circumſtances of the fermentation. In the worts from the mixed griſt, they were greater, on account of the previous ſtrength, than in thoſe from the pure Malt. On the other hand, the acquired attenuations of the latter were often ſo low as zero, or very near it, while of the former, at an average, they ſtood at 1006.

To exhibit a view of the ordinary progreſs of the fermentation, with regard both to temperature and attenuation, we ſubjoin three examples, the laſt of them taken from a Brewing of pure Malt. See Table, N° XXI.

TABLE XXI.

Shewing the Progreſs of Fermentation in Three Brewings.

Date of Brewing.	Days.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1805. Auguſt 15th. Raw Grain & Malt.	Quantity of Yeaſt in Wine Gallons, added each Day - - -	9	3	9	6	0	0	0	0	0	0	0	0
	Temperature each Day	-	63	69	70	80	81	82	80	78	77	Diſtilled.	
	Specific Gravity, at 60.	-	1055	51.7	37.7	22.6	11	07.7	05.7	05.7	05.3		
October 22d. Raw Grain & Malt	Yeaſt - - - - - -	9	8	10	0	0	0	0	0	0	0	0	
	Temperature - - -	-	66	71	74	76	74	74	73	72	72	70	Diſtilled.
	Specific Gravity - -	-	1043.2	30.5	20	16.2	14.2	9.4	07.	04.6	04.	03.7	
November 2d. Malt.	Yeaſt - - - - - -	9	12	4	4	0	0	0	0	0	0		
	Temperature - - -	-	70	82	80	78	77	75	75	73	69	Diſtilled.	
	Specific Gravity - -	-	1034.8	04.3	01.8	01.6	01.6	01.4	01.1	00.8	00.7		

Fermentibility of Extract.

While examining the attenuation of the different worts, two queſtions occurred, both of conſiderable importance, and very cloſely connected with the grand object of this inveſtigation. The firſt is, whether the extract and the worts from the different ſpecies and varieties of Grain, are ſuſceptible, in the ſame degree of fermentation and attenuation, and, with the ſame management, undergo theſe changes to the ſame extent?

When wort ferments, the extract is decompoſed and produces alcohol; and the more complete the fermentation, the greater is the proportion of extract which diſappears. That proportion therefore, is the true meaſure of the fermentible quality. The whole quantity of extract is never conſumed; a portion larger or ſmaller, according to the previous ſtrength or apparent attenuation, always remaining. This is even the caſe, though the acquired attenuation falls below zero. We ſhall not ſtop here to enquire whether the reſidual extract is abſolutely incapable of reſolution and converſion into ſpirit, nor to point out thoſe circumſtances of the waſh itſelf, which tend to make it appear ſo. The queſtion above ſtated, though intricate and of very difficult determination, is already decided in the negative by the world at large; for it is the general opinion, that the extract from Barley poſſeſſes the fermentible property in a greater degree than that from Bigg, and that the extract of both ſpecies of Grain, when raiſed in a good ſoil, ſituation, and climate, is ſuperior, in this reſpect, to that of the ſame Grains produced under leſs favourable circumſtances. This opinion, whether well or ill founded, has in all probability been haſtily formed, and without the ſupport of accurate Experiment. Indeed, from the nature of the ſubject, it is not eaſy to make ſuch Experiments, for this very obvious reaſon, that the reſult may be as much influenced by the circumſtances of the proceſs, as by the quality of the extract, and when a difference in the reſult occurs, it may be impoſſible to diſcover to which of them it ought to be aſcribed.

Mode of eſtimating the ſucceſs of Fermentation.

In eſtimating the fermentible property of different extracts from the ſucceſs of the fermentation, a difficulty occurs with regard to the beſt manner of judging of that ſucceſs. On this occaſion, the ſaccharometer has commonly been reſorted to; but its indications, as has been already pointed out, have not been well underſtood. We can form no judgment of the ſucceſs of any fermentation, either by the *apparent* attenuation or by the *acquired*. We can

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judge better by the proportion which the *apparent* attenuation bears to the original gravity; but quite correctly, by aſcertaining the proportion of extract which actually is conſumed. This may be eaſily done. Aſcertain the quantity of extract remaining undecompoſed in the waſh, either by evaporating a certain quantity of the fluid to dryneſs, or more expeditiouſly, and with leſs chance of error, by the ſaccharometer, after the ſpirit has been diſſipated by boiling, and pure water has been added in the manner already deſcribed. Then compare this reſidual quantity with the original contents of the wort, and you get the proportion ſought. By following this method, we can fairly compare the ſucceſs of one fermentation with that of another: thus, if the extract, at firſt amounting, in one caſe, to ſeventy pounds, is by fermentation reduced to ten pounds exiſting in the waſh, and in another, ſtarting at fifty pounds, it falls to five pounds; then in the former, the fermentation has deſtroyed $\frac{6}{7}$ths, or ·86 per cent. of the extract, and in the latter, $\frac{9}{10}$ths or 90 per cent. and the fermentation of the one is four per cent. better than the other.

Some circumſtances altogether unavoidable, which are explained in another part of the Report, rendered it impoſſible for us to determine, with abſolute preciſion, the original ſtrength of the worts, and deprived us of the opportunity of examining this important point with ſufficient minuteneſs. We can only therefore obſerve in general, that no marked difference in fermentible quality, ſo far as we could judge by the indications of the ſaccharometer, occurred in the worts drawn from the different ſpecies of Grain. It is true, that all the worts did not ferment equally well; but thoſe that fermented ill, were not the produce of one ſpecies or denomination of Grain more than of another. We were indeed ſatisfied that the differences were owing, in a great meaſure, to the circumſtances of the operation itſelf. In the caſe of one kind of Grain, however, it was otherwiſe. The worts from a parcel of Engliſh Barley of the middling quality, in eight trials, fermented badly. Perhaps, in ſeaſons when Grain is more unequal than it was in 1804, the difference of fermentative quality may be more conſpicuous, than it appeared to us.

Different extracts yield the ſame proportion of Spirit.

The ſecond queſtion of conſequence which occurred was, whether the ſame quantity of the extract of different ſpecies and varieties of Grain, which actually diſappears during fermentation, furniſhes the ſame quantity of alcohol? As extract is not ſimply converted into alcohol, but is reſolved partly into it, and partly into the elaſtic fluid, carbonic acid, the queſtion is, does every extract yield theſe in the ſame proportion? The compariſon can only be made between extracts of the ſame nature, and it would not be fair to compare the extract of Malt with that of raw Grain. The moſt convenient opportunity of ſubmitting this point to the deciſion of Experiment, occurred during the Brewery operations. The quantity of extract exiſting originally in the worts, and that remaining in the ales, the quantity of alcohol formed during the fermentation were all carefully aſcertained. Hence it became eaſy to determine the quantity of alcohol ariſing from a given weight of extract that diſappears.

The following Table contains the reſult of five trials, and ſhews the quantity of alcohol of the ſtandard ſtrength, correſponding with each pound of extract, of the different kinds of Malt which diſappeared.

TABLE XXII.

Name of Grain from which the Malt was made.	Quality of Grain.	Quantity of Alcohol .825 in Wine Gallons from each lib. of Extract.
Norfolk Barley - - - -	Firſt - - - - - -	0. 0811
Norfolk Barley - - - -	Second - - - - -	0. 0871
Suffolk Barley - - - -	Firſt - - - - - -	0. 08106
Haddington and Berwick -	Firſt - - - - - -	0. 08588
Ayr Bigg - - - - - -	Second - - - - -	0. 08098
Average - -	- - - - - - -	0. 08323

The

The difference among theſe quantities is not conſiderable. That between the produce of the beſt Engliſh Barley and Bigg, of the ſecond quality, does not exceed $\frac{1}{800}$th part. Hence it may be ſafely concluded, that the other differences fall within the limits of variation unavoidable in ſuch Experiments. The near coincidence of the whole begets confidence in their accuracy.

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From theſe trials, the inference is, that an equal quantity of ſpirit aroſe from the decompoſition of equal quantities of the extract of each of theſe different kinds of Malt: and as theſe Malts were made from parcels of Grain, that differed as much from one another as any we had under examination, we are diſpoſed to think that the extract of the other Malts would have given a ſimilar reſult. If the average of theſe five Experiments be taken, then each pound of extract of Malt which diſappears, actually goes to the formation of 0.08323 wine-gallons or .5736 libs. of ſtandard alcohol.

This, and all the preceding concluſions reſpecting attenuation, &c. we muſt here particularly remark, can only hold good, when the worts have been properly fermented, and have not been permitted to run much into acidity; for when acid is produced, a change of ſpecific gravity different from that ariſing from alcohol takes place, and the proportion of alcohol is diminiſhed.

We ſhall conclude this part of the ſubject by preſenting a tabular view of the facts, taken from the Brewery, reſpecting the *apparent*, *real*, and *acquired* attenuations, which have been under diſcuſſion, and of the data from which we have deduced the relations between the apparent attenuation, and the quantity of alcohol generated, and likewiſe between the quantity of extract conſumed, and the produce of alcohol.

Table of Attenuations, &c.

TABLE

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TABLE

Exhibiting the different Attenuations, and the Relation both between and between the Quantity of Extract conſumed,

1.	2.	3.	4.	5.	6.
Name of Grain from which the Malt was made.	Saccharometer Degree of the Wort by the Inſtrument of Dring & Fage.	Quantity of Extract per Ale Barrel in Libs.	Saccharometer Degree of the Ale or *acquired* Attenuation.	Saccharometer Degree of the Ale after the Diſſipation of the Spirit and addition of Water.	Difference between N° 4 and N° 5, ſhewing the attenuation ariſing from the Spirit.
Norfolk Barley. 1ſt Quality - - - - -	39.625	101.043	9.5	14.5	5.
Norfolk Barley. 2d Quality - - - -	39.5	100.725	15.	19.125	4.125
Suffolk Barley. 1ſt Quality - - - - -	45.	114.75	19.25	23.25	4.
Haddington and Berwick 1ſt Quality - - - - -	42.5	108.375	17.625	22.25	4.625
Ayr Bigg. 2d Quality - - - - -	39.375	100.406	13.75	18.125	4.375

Column 1ſt. exhibits the ſort of Malt brewed.
—— 2d. the ſaccharometer degree of the wort, by the inſtrument of Dring and Fage.
—— 3d. the quantity of extract in each ale barrel of the wort, expreſſed in pounds avoirdupois.
—— 4th. the ſaccharometer degree of the ale, that is, the *acquired* attenuation.
—— 5th. the ſaccharometer degree of the ale, after the ſpirit was diſtilled off, and the original quantity of fluid made up by pure water.
—— 6th. the difference between the laſt two, indicating the amount of the attenuation occaſioned by the preſence of ſpirit.
—— 7th. the total amount of attenuation—i. e. *apparent* attenuation.
—— 8th. the amount of the attenuation occaſioned by the conſumption of the extract, i. e. the *real* attenuation.
—— 9th. the quantity of extract ſtill remaining in the worts.
—— 10th. the quantity of extract which has diſappeared.
—— 11th. the quantity of alcohol .825, actually produced in each ale barrel, expreſſed in wine gallons.
—— 12th. the quantity of alcohol formed during every degree of *apparent* attenuation, expreſſed in wine gallons.
—— 13th. the quantity of alcohol produced from each pound of extract which diſappears, alſo expreſſed in wine gallons.

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XXIII.

the Degree of Attenuation and the Quantity of Alcohol produced,

and the Quantity of Alcohol produced.

7.	8.	9.	10.	11.	12.	13.
Apparent Attenuation.	*Real* Attenuation from the Loſs of Extract.	Quantity of Extract remaining.	Quantity of Extract which has diſappeared.	Quantity of Alcohol .825 produced per Barrel, expreſſed in Wine Gallons.	Quantity of Alcohol ariſing from one Degree of *apparent* Attenuation in Wine Gallons.	Quantity of Alcohol from each lb. of Extract which diſappears in Wine Gallons.
30.125	25.125	36.975	64.068	5.19650	.17249	0.08110
24.5	20.375	51.956	48.769	4.24985	.17346	0.08714
25.75	21.75	59.287	55.462	4.49624	.17461	0.08106
24.875	20.25	56.737	51.637	4.43497	.17668	0.08588
25.625	21.25	46.218	54.187	4.38847	.17125	0.08098
			Average - - - -		.17369	0.08323

IV. The Diſtilling.

The laſt operation conſiſts in ſeparating from the other parts, by diſtillation, the ſpirit formed during the fermentation. In it, the great object is to detach the whole of the ſpirit from the waſh, and to collect it without loſs. The ſeparation depends upon the difference of volatility ſubſiſting between ſpirit and water, and with ſkill and attention in the uſe of a proper apparatus, is quite under command.

Dimenſions of Still.

It is well known that two different modes of diſtilling are followed in this country; namely, what is called the ſlow mode, in which deep ſtills of a large capacity are employed, and the rapid mode, in which ſmall ſhallow ſtills are uſed. Several conſiderations of conſequence determined us to give the preference to the latter. The ſtill employed was capable of containing 108 gallons. It had the flatted form; but in this reſpect, it fell much ſhort of thoſe ſtills that are calculated for the moſt rapid diſtillation. Its diameter was 4 feet, and its depth 11.8 inches. It was provided with the uſual internal machinery of iron chains and a circular plate. The former prevent the ſubſidence and adheſion of the thick matter of the waſh to the bottom, and ſo guard againſt the ſpeedy deſtruction of the ſtill; and, at ſame time, defend the ſpirit from being ſpoiled by the offenſive and unconquerable flavour which the ſediment, when ſcorched, imparts. The latter, by breaking the bubbles which ariſe during rapid ebullition, leſſens the riſk of boiling over, or "running foul," and ſo permits a greater "charge" of waſh to be put into the ſtill.

To obtain ſpirits from waſh, two diſtillations are neceſſary. The firſt, which is termed "ſingling," produces "Low Wines," a weak and impure ſpirituous liquor. The ſecond, named "doubling," the ſtronger ſpirit, called in Scotland, Whiſkey.

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Whiſkey. In conducting both, much more time was taken in our operations than is allowed, or can be afforded, in ordinary Diſtilleries.

Uſe of Soap.

The ſtill worked well with a charge of 42.4 gallons of waſh, and was run off at an average of many hundred trials, in ſixteen minutes and a half, yielding on the ſame extenſive average, 15.9 gallons of low wines. Though the waſh filled ſcarcely more than two-fifths of the capacity of the ſtill, and though the Diſtillation was carried on with a celerity greatly inferior to what is the common practice of Diſtillers, it was impoſſible to avoid the uſe of ſoap. The introduction of this article has been accuſed, perhaps with ſome juſtice, as one ſource of the diſagreeable flavour of whiſkey diſtilled in the rapid manner of the Scottiſh Diſtillery. It cannot, however, be omitted, and the riſk of contaminating the ſpirit muſt be obviated by uſing ſoap of a fine quality, in the ſmalleſt poſſible quantity that will anſwer the purpoſe. The quantity of ſoap employed in our trials, was between two and three ounces to every charge of 42 gallons. When waſh begins to boil, much elaſtic fluid iſſues from it: if the ebullition be briſk, it is then diſengaged with rapidity, and cauſes the liquor to riſe in a multitude of bubbles; forming a thick froth, which ſwells and runs over into the worm. The uſe of ſoap is to prevent this intumeſcence; and its efficacy is very remarkable. It may be well obſerved by heating waſh in veſſels of glaſs. As ſoon as the ebullition has produced the frothy head, which threatens to ſwell and flow over the mouth, throw in ſome ſmall pieces of ſoap, and the frothy head will be ſeen immediately to fall. If the ſoap be thrown into the waſh when cold, the pieces, at firſt, fall to the bottom; but juſt before the ebullition begins, they riſe to the top and are quickly diſſolved. No froth now gathers on the fluid, and when the boiling takes place, the elaſtic vapour throws the fluid into agitation, but does not elevate any bubbles above the ſurface.

In conſequence of the diſagreeable taſte communicated by ſoap, we tried a number of other ſubſtances, in the hope of finding one that would anſwer the end better: conceiving that the elaſtic fluid, the eſcape of which, in the firſt inſtance, produces the commotion, was carbonic acid, which all fermented liquors contain, and that the ſoap operated, in part, by virtue of its alcaline baſe attracting this acid, we attempted to attach it by pure potaſh, and by lime.

The acidity of the waſh was removed; but the liquor, particularly when lime was tried, though filtered clear, ſwelled even more than pure waſh, and could ſcarcely be reſtrained by ſoap. Oil was the only ſubſtance tried, which poſſeſſed the ſame property as ſoap: hence it is probable, that the acidity obſerved in waſh, may contribute to the efficacy of the ſoap, by decompoſing it, and diſengaging a part of the oleaginous matter which that ſubſtance contains. The only mode of avoiding the neceſſity of uſing ſoap is, to heat the waſh when arrived within 20° of its boiling point, very ſlowly, that it may begin to boil in the gentleſt manner. After the ebullition has fairly begun, the heat may be increaſed without much danger. But this plan cannot be followed while the preſent mode of levying the Duty on ſpirits continues.

Precaution in Still Houſe.

In the ſtill-houſe, we conceived it neceſſary, with a view of obviating the chance of miſtake, or fraud, to redouble our attentions, and multiply our checks. Every minute occurrence was recorded, and every product carefully gauged and examined. To have a check on our previous eſtimates of the quantity of waſh, every charge of the ſtill was meaſured in a ſmall cylindrical "charging back" of copper, accurately gauged, and the amount of the whole thus aſcertained. The time of running off was marked, and the low wines were meaſured; firſt, by receiving them into a covered "ſafe," previouſly gauged, and afterwards, when the whole were collected, by the gauge of the "receiver." Their ſtrength was then eſtimated by Dicas' hydrometer, and by taking the ſpecific gravity of many of them. As it was eſſential that all the ſpirit ſhould be extracted from the waſh, the ſtill was not diſcharged till after it had, for ſome time, been yielding a watery fluid deſtitute of ſpirit.

The diſtillation of the low wines, or "doubling," was conducted with ſimilar precaution. The quantity of each charge was determined by the ſmall charging-back, and the produce of each likewiſe aſcertained, by receiving the ſpirit into its appropriate covered ſafe. From this, the ſpirit was conveyed into the receiver, 1. Report of Experiments on Malt made from Barley and Scotch Bigg.

receiver, where its quantity and temperature were examined. In the proceſs of "doubling," it was of conſequence that all the ſpirit ſhould be diſtilled from the low wines, and collected without loſs. The uſual practice was followed, by collecting the product in three ſeparate portions. The milky fluid which firſt comes over, named the "foreſhot," was received into the "low wine ſafe," and reconveyed to the low wines. The pure liquor that ſucceeds, was collected in its ſafe, till it gradually fell in ſtrength to the point when it gets the name of "feints." Theſe were always permitted to run till the hydrometer indicated the ſpecific gravity of pure water, and were then conveyed to the low wines.

The charge of the ſtill with low wines, was 59.5 gallons. The average time in which it was diſcharged, including the period of the flow both of the ſpirit and feints, was 38½ minutes: the average produce of ſpirit, excluſive of "foreſhot" and feints, amounted to 11.5 gallons.

Soap is not uſed in doubling. It is cuſtomary, however, to throw in, with each charge, ſome common ſalt. The quantity uſed is probably too ſmall to be of much ſervice; but the way in which it acts is obvious. The ſalt is diſſolved by the water, and its attraction for this fluid weakens that of the ſpirit, and, at the ſame time, by repreſſing the volatility of the water, favours the ſeparation of the other.

Strength of Spirits.

As ſoon as the ſpirits procured from each Brewing were diſtilled off, their bulk, temperature, and ſtrength were aſcertained with the greateſt care. The ſtrength of the ſpirit is determined by its ſpecific gravity; and it has always been the language of ſcience to denote the former by expreſſing the latter. This language, however, was deſtitute of preciſion, till the Experiments and Tables of Sir Charles Blagden and Mr. Gilpin appeared, which indicated the quantity of alcohol of the ſpecific gravity of .825, correſponding with every degree of ſpecific gravity.

By the Exciſe laws at preſent exiſting in this country, the Duty on ſpirits is levied by the *bulk*, eſtimated at a particular ſtrength, to which all ſpirits are brought by a ſet of Tables. This ſtrength is regulated by a very inconvenient hydrometer, invented by Mr. Clarke in 1730; ſince which time it has undergone various changes and improvements. It was adapted to an abſurd language, which having previouſly come into common uſe among Dealers, ſeems from them to have made its way into the exciſe laws. A mixture of equal parts, by *bulk*, of alcohol and water, was called "*proof ſpirit*," and choſen as a ſtandard to which ſpirits of every other ſtrength were to be reduced. But the real ſtrength of proof ſpirits was long ambiguous. By an Act of Parliament, paſſed in 1762, they ought to be of the ſpecific gravity 0. 916, at the temperature of 60°. But Clarke's hydrometer, which is the legal ſtandard at preſent, gives 0. 920 for their ſpecific gravity, at the ſame temperature.

Proof or Standard
Spirit
sp. grav.
920 by [illegible]

The ſtrength of ſpirits *above proof* is indicated on Clarke's hydrometer, by the *bulk* of water neceſſary to reduce a given bulk of the ſpirits in queſtion to proof. Thus, if it be neceſſary to mix one gallon of water with ten gallons of a given ſpirit, to bring it to proof, that ſpirit is ſaid to be 1 to 10 *over proof*. The ſtrength of ſpirits *under proof*, is eſtimated by the bulk of water which it would be neceſſary to abſtract, to bring them to the ſtrength of proof.

Thus, if from 10 gallons of a given ſpirit, it would be neceſſary to take one gallon of water to bring it to proof, the ſpirit is ſaid to be 1 in 10 *under proof*. Of theſe two methods of eſtimating the *ſtrength* of ſpirits, the former is by far the moſt accurate and convenient: yet, in ſtating the quantity of ſpirit produced, we have adopted both modes of expreſſion, and to obtain them, had to examine the ſtrength by a variety of inſtruments.

Leſt there ſhould ſubſiſt any difference in the hydrometers, we made a point of uſing the ſame individual inſtrument in all our trials, and, for the ſake of correctneſs, at the ſame temperature: it gave us the expreſſion of the ſtrength in the language of the Exciſe; but in the uſe of this language, perſons converſant in the buſineſs are not uniform. Some, in ſpeaking of ſpirits, conſider them of the ſtrength of proof; others of the legal ſtrength of 1 to 10 *over* proof; and Diſtillers always ſell at 1 in 10 *under*. That our reſults might be readily underſtood, we have ſtated them under each of theſe forms of expreſſion.

Such was the general mode of procedure adopted in conducting this branch of the inveſtigation. To ſhew in what manner our record of all the circumſtances was arranged, we ſubjoin a view of a ſingle Experiment.

TABLE

Tabular View of one Experiment.

TABLE XXIV—VIEW OF O

I. Raw Grain and Malt.

Date. — 1805.	Number of Brewing.	Grain, &c.		Quality.	Buſhels.	Weight per Buſhel.	Total Weight in Libs.		Change of Weig in Grinding.
			County.				Unground.	Ground.	
October 29th - -	87	Barley.	Suffolk.	1	40	50.79	2031.5	2013.5	— 18.0
		Malt.	Kent.	1	20	39.35	787.125	787.375	+ 0.25

III. Worts of Firſt Maſh, on Coolers.

Date. — 1805.	Number of Brewing.	Time in Cooling.	Quantity.		Temperature at letting down.	Strength.		
			Depth.	Gallons.		Temperature.	Sp. Gr.	Dicas.
October 29th - -	87	2° 5′	2.6	395.	66.	- - -	54.25=5412	100=51

V. Worts of Second Maſh, on Coolers.

Date. — 1805.	Number of Brewing.	Time in Cooling.	Quantity.		Temperature at letting down.	Strength.		
			Depth.	Gallons.		Temperature.	Sp. Gr.	Dicas.
October 29th - -	87	1°	2.6	349	68	- - -	55°	1005=51.5

VII. Worts of Third Maſh, on Coolers.

Date. — 1805.	Number of Brewing.	Time in Cooling.	Quantity.		Temperature at letting down.	Strength.		
			Depth.	Gallons.		Temperature.	Sp. Gr.	Dicas.
October 29th - -	87	4° 45′	3.5	486	58.	- - -	36°=39.62	75=35.12

IX. Waſh Ba

Date. — 1805.	Number of Brewing.	Number of Tun.	Waſh Back.		DAYS.			
			Depth.	Gallons.	Days.	1.	2.	3.
October 29th - -	87.	5	21	1436	Yeaſt - - - -	9	8	10
	- -	- -	20.5	1448	Temperature - {	In Back.	70	72
	- -	- -	Diſtilled.			When tried.	67	70
	- -	- -			Specific Gravity -	- - -	43=43.7	23 5=
	- -	- -	- -	1448	Dicas - - - -	- - -	84.75=40.75	61.25=

X. Diſtillation of Low Wines.

Date. — 1805.	Number of Brewing.	Waſh Back.		Number of Charges.	Average Charge and Time.	Aver ge Produce from a Charge.	Total of Low Wines.	Strength.		
		N°.	Gallons.					Temp.		D
November	87.	5	1448	34	42.68	15.09	L. 0	50	- -	33.5
9th & 11th	-	Charges.	1451.10	- - -	Time.	- -	C. 34.2519.35	- -	- -	
Suffolk 1ſt - -	- -	- -	- - -	591=5.51	17 13.	- -	Safe 513.25	- -	- -	

PERIMENT IN THE DISTILLERY.

II. Firſt Maſh in Tun.

1805. — Date.	Number of Brewing.	1ſt Liquor.			D. Malt added.		Liquor added.		Tempt. at Cock.	Duration of	
		Depth.	Gallons.	Temp.	Depth.	Gallons.	Inches.	Temper.		Maſhing.	Infuſion.
er 29th - -	87.	24	723.8	150	31.2	942.2	- -	182	128	1° 30′	1° 10′

IV. Second Maſh in Tun.

Date. — 1805.	Number of Brewing.	Liquor added.		Maſh Tun.			Tempt. at Cock.	Duration of	
		Temperature.	Gallons.	Temperature.	Depth.	Gallons.		Maſhing.	Infuſion.
ber 29th - -	87.	193	278.5	144	38.9	1025.5	136	20″	45′

VI. Third Maſh in Tun.

Date. — 1805.	Number of Brewing.	Liquor added.		Maſh Tun.			Temperat. of Cock.	Duration of	
		Temperature.	Gallons.	Depth.	Gallons.	Temperature.		Maſhing.	Infuſion.
ber 29th - -	87.	198	483.5	35	1059.6	162	157	15″	45′

VIII. Fourth Worts, in Small Boiler.

Date. — 1805.	Number of Brewing.	Quantity.		Temperature.	Strength.			Grains.
		Depth.	Gallons.		Temperature.	Sp. Gr.	Dicas.	
ober 29th - -	- -	22.5	100.15	103	89	425=44	845=4125	18.5451

l Fermentation.

DAYS.									
4.	5.	6.	7.	8.	9.	10.	11.	12.	
8	0	0	0	0	0	0	0	0	—
74	77	78	76	74	71	70	70	69	} Diſtilled.
73	74	74	75	72	70	68	68	66	
=26.25	16=17.5	10.25=11.62	7.25=8.75	6.25=7.5	55=6.6.2	5.25=6.4	5=587	5=5.62	—
=23 25	48.5=16.25	40.5=11.	36.=7.12	34.5=6.75	33.75=6	33.25=55	33=5.25	33=5.25	—

XI. Diſtillation of Spirits.

Date. — 1805.	Low Wines.		N° of Charges and Time.	Average of a Charge.	Total of Spirits.			Strength.			
		Gallons				Dip.	Gallons.	Tempt.	Sp.Gr	Dicas.	Clark.
vember 11th -	Receiver. Charges. Feints.	519.35 595.00 75.65	10 Time. 336′=5° 36	59.50 33′ 6	Spirit Recʳ Hogſheads. Charges. Average from Charge 13.3	12.3 - -	Temper. 66 132.02 130.5 130.13	60 Hydʳ - Bead - Mean -	919 917 918	144=0.25 - - - - - -	p X 2 — —

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

Having ſtated the general circumſtances, we have now to lay before the Honourable Board the reſult of the particular Experiments by Diſtillation. They were numerous; and were all the circumſtances recorded in the Journals deſcribed in detail, this Report would ſwell to an inordinate ſize. We ſhall therefore confine ourſelves to thoſe which ſeem neceſſary to give a diſtinct view of the general facts and reſults of each trial, and ſhall throw it into the form of a Table, in order to render it as clear and as ſuccinct as poſſible.

In this Table, the circumſtances exhibited are the kind and quality of the Grain and Malt; and the weight of each per buſhel; the quantity of Waſh drawn at each brewing, and the attenuation which it undergoes; the quantity of Low Wines and of Spirits obtained in Diſtillation, expreſſed in the language of trade, as well as that of ſcience; and laſtly, the produce of Spirits, eſtimated per quarter, boll, buſhel, and pound. The Table contains 14 columns, under which theſe circumſtances are preſented in the following order:

TABLES

OF

DISTILLERY EXPERIMENTS.

TABLE XXV. Part I.—Firſt Suite

Scotch Barleys,

1.		2.	3.	4.	5.	6.	7.		
Kinds of Grain, and of Malt.		Weight, per Buſhel.	Number of Brewings.	Gallons of Waſh.	Specific Gravity of Wort and of Waſh.	Quantity of Low Wines and Strength, per Dicas.	Quantity of Spirits.		
							Spirit Rec. Temperat. Strength.	1 to 10 over.	Proof.
Haddington	G.	52. 28	13	1231.	49. 5 01. 3	987. 35	271. 21 T. 80 1 to 15—7½	255, 417	280. 987
	M.	38. 99	14	1169	52. 0 04. 2	—			
Edinburgh	G.	51. 67	15	979	66. 8 08. 6	1046. 25	290. 75 T. 82 1 to 20—1	274. 909	302. 43
	M.	38. 98	16	1458	70. 2 15. 2				
							English Barley,		
Suffolk	G.	50. 83	17	1146	46. 7 05. 6	945. 35	251. 53 T. 80 1 to 20 × 7½	242. 067	266. 3
	M.	42. 24	18	1117	65. 6 07. 5	—70			
Kent	G.	50. 67	19	1040	63. 4 04. 6	825.	256. 81 T. 80 1 to 10—3	252. 316	277. 57
	M.	39. 08	20	1053	67. 5 08. 3	—66			
Norfolk	G.	50. 76	21	1442	67. 2 10. 5	1154. 64	338. 1 T. 81 1 to 20—4	316. 272	347. 93
	M.	39. 65	22	1435	50. 8 03. 5	—69. 5			
							Scotch Bigg		
Perth	G.	49. 25	23	1183	46. 4 03. 7	1037. 12	258. 3 T. 77 P. × 8	237. 152	260. 88
	M.	38. 37	24	1118	51. 2 02. 4	—72. 75			
Aberdeen	G.	49. 61	25	1146	64. 4 07. 6	969. 09	265. 03 T. 80 P. × 10½	244. 835	269. 33
	M.	41. 02	26	1165	62. 5 13. 3	— 70			
Lanark	G.	48. 96.	27	1506	57. 6 05. 5	1245. 26	332. 62 T. 87 P.—7½	293. 293	322. 6
Half Lanark and half Dumfries	M.	39. 09	28	1528	51. 4 03. 6	— 71			
							Scotch Barle		
Perth	G.	43. 2	29	1156. 5	47. 2 05. 6	1088. 71	256. 81 T. 80 P.—9¼	225. 721	248. 3
	M.	40. 51	30	1220. 5	55. 0 05. 2	—75. 3			
Linlithgow	G.	50. 98	31	1172	56. 5 03. 8	992. 46	284. 82 T. 83. 1 to 20 × 2½	270. 845	297. 9
Perth and Fife	M.	41. 38	32	1193	63. 7 04. 0	— 70			
Edinburgh	G.	50. 61	33	1436	55. 4 05. 5	1077. 63	301. 03 T. 83 P × 8½	276. 566	304. 2
Perth and Angus	M.	39. 97	34	1284	53. 8 07. 6	— 71			

XPERIMENTS by DISTILLATION.

irſt Qualities.

8.		9.			10.		11.	12.	13.	14.	
Average of Spirits er Quarter.		Average of Spirits per Boll.			Average of Spirits per Buſhel.		Total Weight of Grain & Malt, after Grinding, and in Maſh.	Average Weight of Mixture per Buſhel.	Quantity of Proof Spirits, from 100 Pounds, in Gallons.	Quantity of Alcohol .825 in libs.	
to 10 ver.	Proof.	1 to 10 over.	Proof.	1 in 10 under.	1 to 10 over.	Proof.				Per Buſhel.	Per 100 lbs.
.676	19.447	13.257	14.585	16.20	2.2096	2.4309	11258.811	46.911	5.1314	10.3159	
irſt Qualities.											
.014	19.817	13.510	14.863	16.516	2.2518	2.4772	16890.637	46.918	5.2790	10.348	22.075
irſt Qualities.											
.228	18.952	12.921	14.214	15.795	2.1535	2.369	16438.748	45.663	5.1881	10.045	21.99
econd Qualities.											
.180	18.899	12.885	14.174	15.751	2.1475	2.3624	16747.373	46.520	4.9709	9.969	21.43

2. Report of Experiments on Malt made from Barley and Scotch Bigg.

TABLE XXV. Part II.—First Suite of

English Barley,

1.		2.	3.	4.	5.	6.	7.		
							Quantity of Spirits.		
Kinds of Grain and of Malt.		Weight per Bushel.	Number of Brewings.	Quantity of Wash.	Specific Gravity of Wort and of Wash.	Quantity of Low Wines and Strength per Dicas.	Spirit Receiver Tempt. Strength.	1 to 10 over.	Proof.
Suffolk - - -	G.	49. 25	35	1280	43. 6 07. 7	951. 07	223. 44 T. 80 1 in 20 + 13	197. 303	217. 055
	M.	38. 15	36	1053	47. 7 06. 0	—75. 75			
Kent and Suffolk	G.	49. 74	37	1058	61. 1 04. 0	939. 66	259. 89 T. 83 1 to 20 + 6½	249. 61	274. 598
	M.	38. 51	38	1169	47. 8 09. 0	—73.			
Kent - - -	G.	50. 15	39	1306	35. 5 09. 4	1156 29	285. 60 T. 82 P. + 7	261. 574	287. 742
	M.	38. 20	40	1497	61. 6 06. 7	—73. 25			
							Scotch Biggs,		
Mearns - - -	G.	48. 48	42	1225	40. 4 01. 0	979. 06	258. 86 T. 80 P. × 13	240. 611	264. 684
	M.	39. 27	43	1209	44. 0 02. 2	—71. 5			
Angus - - -	G.	48. 21	44	1149	54. 2 05. 2	962. 73	274. 25 T. 80 P. × 13.	254. 911	280. 420
	M.	40. 30	45	1179	57. 6 01. 7	—71.			
Dumfries - -	G.	48. 60	46	1395	58. 4 02. 1	1194. 09	327. 57 T. 82 P. — 1	295. 543	325. 114
	M.	40. 04	47	1471	48 2 04. 6	—72			
							Scotch Barley,		
Linlithgow - -	G.	47. 77	48	1063	46. 4 08. 2	908. 64	223. 44 T. 82. 5 P. + 10	206 15	220. 791
	M.	42. 24	49	[illegible]	54. 4 08. 5	—73. 5			
Perth - - - -	G.	49. 026	50	1147	54. 6 06 8	896. 34	264. 01 T. 79. 5 1 to 20 + 6	253. 254	278. 607
Linlithgow - -	M.	41. 41	51	1116. 8	58. 6 07. 5	—69			
Haddington & Angus	G	49. 51	52	1458. 5	51. 2 08. 1	1159. 27	289. 72 T. 74 P. + 5	264. 682	291. 16
Berwick - - -	M	39. 71	53	1380. 5	57 2. 07. 8	—			
							English Barley,		
Essex - - -	G.	- -	54	1116	42. 2 04. 0	932. 89	218. 23 T. 80 1 to 20	206. 214	226. 858
	M.	- -	55	1225	49. 7 08. 1	—74. 7			
	G.	48. 22	56	1170	52. 7 09. 0	921. 65	256. 81 T. 79 P. + 13	238. 704	262. 588
	M.	39. 33	57	1225	56. 4 05. 7	— 71			
	G.	- -	58	1553	52. 4 05. 6	1125. 3	301. 03 T— 78 1 to 25 × 2½	286. 258	314. 915
	M.	- -	59	1540	52. 2 07. 7	— 71. 25			

2
Report of Experiments on Malt made from Barley and Scotch Bigg.

EXPERIMENTS by DISTILLATION—*continued.*

8.		9.			10.		11.	12.	13.	14.	
Average of Spirits er Quarter.		Average of Spirits per Boll.			Average of Spirits per Buſhel.		Total weight of Grain and Malt, after Grinding and in Maſh.	Average Weight of Mixture per Buſhel.	Quantity of Proof Spirits from 100 lbs. in Gallons.	Quantity of Alcohol. .825 in Pounds.	
to 10 ver	Proof.	1 to 10 over.	Proof.	1 in 10 under.	1 to 10 over.	Proof.				Per Buſhel.	Per 100 libs.
Second Qualities.											
.744	17. 319	11. 808	12. 989	14. 43	1. 9680	2. 1649	16400. 496	45. 556	4. 7522	9. 0813	19. 92
Second Qualities.											
579	19. 337	13. 184	14. 503	16. 117	2. 1974	2. 4172	16323. 618	45. 343	5. 3310	10. 1445	22. 30
Third Qualities.											
090	17. 700	12. 0678	13. 275	14. 752	2. 0113	2. 2126	16497. 296	45. 825	4. 8284	9. 2639	20. 21
Third Qualities.											
248	17. 874	12. 186	13. 405	14. 897	2. 0310	2. 2343	16160. 997	44. 891	4. 9772	9. 355	20. 12

TABLE XXV. Part III.—Firſt Suite of

Scotch Bigg,

1.	2.	3.	4.	5.	6.	7.		
Kinds of Grain, and of Malt.	Weight per Buſhel.	Number of Brewings.	Gallons of Waſh.	Specific Gravity of Wort and Waſh.	Quantity of Low Wines and Strength per Dicas.	Quantity of Spirits.		
						Spirit Receiver. Temperat. Strength.	1 to 10 over.	Proof.
Aberdeen - - G.	45. 375 47. 75	60	1058	38. 7 01. 8	880. 18	223. 44 T. 78 1 to 20 + 3½	213. 002	234. 325
M.	34. 651	61	1210	41. 7 04. 1				
G.	48. 676 49. 271	62	1362	54. 1 06. 3	1063 — 71. 5	285. 6 T. 79 1 to 20 + 1	270. 557	297. 642
Angus - - - M.	40. 01	63	1364. 5	56. 2 06. 6				
Ayr & Aberdeen - G. Angus - - - M.	47. 295 39. 862	64	1437.	47. 4 01. 2	546. 09 — 72½	138. 34 T. 79 1 to 15 + 3. 75	134. 046	147. 465

Engliſh Barley, Second Qualities,

Suffolk and Kent - G. Kent - - - - M.	49. 53 39. 56	65	1484	41. 7 06. 5	—	—	—	—
Suffolk - - - G. M.	49. 09 38. 96	66	1482	50. 2 08. 5	1126. 74 — 76.	251. 62 T. 73. P.—0.75	228. 268	250. 111

Second Scotch Bigg,

Mearns - - G.	47. 535	67	1113	43. 5 02. 7	963. 46	243. 27 T. 77 1 to 20	229. 878	252. 891
M.	39. 96	68	1452 . 5	52. 7 04. 7				
Dumfries - - G. M.	48. 43 40. 54	69	1405.	53. 4 07. 2	547. 74 — 72	142. 56 T. 73 1 to 20 + 3	136. 074	149. 696

XPERIMENTS by DISTILLATION—*continued.*

ird Qualities.

8.		9			10.		11.	12.	13.	14.	
erage of pirits Quarter.		Average of Spirits per Boll.			Average of Spirits per Buſhel.		Total Weight of Grain and Malt after Grinding and in Maſh.	Average Weight of Mixture per Buſhel.	Quantity of Proof Spirits from 100 lbs. in Gallons.	Quantity of Alcohol, .825 in lbs.	
o	Proof.	1 to 10 over.	Proof.	1 in 10 under.	1 to 10 over.	Proof.				Per Buſhel.	Per 100 lbs.
8	17.732	12.088	13.299	14.777	2.0148	2.2165	10525.937	43.858	5.0538		
2	19.661	13.404	14.746	16.386	2.2341	2.4577	2674.875	44.580	5.5131		

etition of firſt Suite.

7	16.673	11.4132	12.505	13.952	1.9022	2.0842	5483.749	45.697	4.5609	8.8256	19.36

ond Quality.

4	17.892	12.198	13.419	14.911	2.0330	2.2365	8141.187	45.228	4.9451	9.315	20.57

TABLE XXV. Part IV.—Second Suite

Fi

1.	2.	3.	4.	5.	6.	7.		
Kinds of Grain and of Malt.	Weight per Buſhel.	Number of Brewings.	Gallon of Waſh.	Specific Gravity of Wort and of Waſh.	Quantity of Low Wines, and Strength per Dicas.	Quantity of Spirits.		
						Spirit Receiver, Temperature, Strength.	1 to 10 over	Pro
Fife - - - G. Angus - - - M.	51. 475 40. 406	88	1437	43.0 06.0	473.58 — 68	128.85 T. 70 1 to 15 + 7	127.019	139.
Suffolk - - - G. Kent - - - - M.	50. 79 39, 35	87	1448	43.7 05.6	519.35 — 72.5	132.02 T. 66 P + 6.5	121.203	133.
Aberdeen - { Bigg Malt	49. 789 42. 081	81	1541	43.2 03.7	497.46	134.13 T. 63 1 to 20 + 8	130.393	143.

Sec

Fife, Perth, and Linlithgow } Barley Linlithgow - Malt	49.387 39.793	83	1535	39.7 04.6	521.94	135.7 T. 73 1 to 20×2	129.323	142
Norfolk and Suffolk G. Suffolk - - - - M.	49.162 40.625	82	1494	33.5 02.0	560.95	139.4 T. 68½ 1 to 20—8	129.861	142
Angus, Mearns, and Aberdeen } Bigg Aberdeen - - Malt	48.778 40.487	84	1494	36.0 03.3	529.74	134.13 T. 68 1 to 20—8	124.949	137

T

Fife and Angus { G. M.	49.373 40.926	86	1531.5	38.5 04.8	513.40	137.29 T. 73 1 to 20+1	130.439	143
Eſſex - - - - G. Norfolk - - - M.	48.469 40.931	85	1624	35.7 03.7	541.7 — 73	134.13 T. 80 1 to 20—10	123.546	135

XPERIMENTS, conſiſting of Single Brewings.

ualities.

8.		9.			10.		11.	12.	13.	14.	
verage of Spirits r Quarter.		Average of Spirits per Boll.			Average of Spirits per Buſhel.		Total Weight of Grains and Malt, after Grinding and in Maſh.	Average Weight of Mixture per Buſhel.	Quantity of Proof Spirits from 100 lbs. in Gallons.	Quantity of Alcohol .825 in lbs.	
10 er.	Proof.	1 to 10 over.	Proof.	1 in 20 under.	1 to 10 over.	Proof.				per Buſhel.	per 100 lbs.
935	18.631	12.7019	13.973	15.526	2.1169	2.3289	2856.625	47.610	4.8916	9.737	20.45
160	17.779	12.1203	13.334	14.816	2.0200	2.2224	2800.875	46.680	4.760	9.551	20.46
385	19.126	13.0393	14.344	15.940	2.1732	2.3907	2724.125	45.402	5.265	9.884	21.01

ualities.

43	18.969	12.932	14.226	15.809	2.1553	2.3711	2758.375	45.972	5.157	9.912	21.56
14	19.048	12.986	14.286	15.875	2.1643	2.3810	2767.312	46.121	5.162	10.015	21.78
59	18.327	12.494	13.745	15.273	2.0824	2.2909	2740.50	45.675	5.015	9.649	21.13

alities.

91	19.132	13.043	14.349	15.944	2.1739	2.3916	2777.375	46.288	5.166	9.991	21.59
72	18.121	12.354	13.591	15.103	2.0591	2.2652	2733.562	45.559	4.972	9.579	21.03

TABLE XXV. Part V.—Third Suite

Fi

1.	2.	3.	4.	5.	6.	7.			8.	
Kinds of Malt and of Grain.	Weight per Buſhel.	Number of Brewings.	Gallons of Waſh.	Specific Gravity of Worts and of Waſh.	Quantity of Low Wines, and Strength per Dicas.	Quantity of Spirits.			Averageof per Quart	
						Spirit Rec. Temperat. Strength.	1 to 10 over.	Proof.	1 to 10 over.	Pr
Barley Malt. Suffolk - - - - - -	41.924	70	1922	26. 8 00. 99	722.99 — 77	161.828 T. 72 Proof.	146.219	160.857	19.495	21.
Barley Malt. Suffolk and Kent - -	42.03	78	1458	38.6 00.7	568.90 — 72	150.70 T. 70 1 to 20 + 10	146 721	161.409	19 562	21.
Barley Malt. Haddington&Linlithgow	40.99	71	1201	51.2 04 5	467.14 — 70	137.49 T. 73 1 to 20—3	129.455	142.414	17.260	18.
Bigg Malt. Aberdeen - - - -	41.801	72	1364	48.5 01.3	531.23	129.91 T. 77 1 to 10	128.871	141.772	17.182	18

Seco

Barley Malt. Kent - - - - - -	40.846	73	1394	46.2 00.0	586.27	140.98 T.—75 P. + 8	129.818	142.812	17.308	19
Barley Malt. Linlithgow - - - -	39.48	74	1505	41.5 00.7	601.05	139.40 T. 70 P. + 1	126.396	139.051	16.852	18
Bigg Malt. Perth, Angus, Dumfries, Kirkcudbright, & Aberdeen - - -	39.163	90	1514.5	38.7 00.3	556.84	136.23 T. 76 P.—7	120.678	132.757	16.090	17

Th

Barley Malt. Eſſex - - - - - -	38.433	89	1588.5	34.8 00.7	543.11	143.09 T. 70 1 to 20—1½.	135.379	148.931	18.050	19
Barley Malt. Berwick & Edinburgh -	41.998	77	1417.	39.7 04.6	541.14 — 71	142.03 T. 65 P. + 12	132.65	145.935	17.686	19

PERIMENTS, Malt alone.

ities.

9.		10.		11.	12.	13.	14.		15.	16.
erage of Sp^{ts} per Boll.		Average of Sp^{ts} per Buſhel.		Total Weight of Grain and Malt after Grinding and in Maſh.	Average Weight of Mixture per Buſhel.	Quantity of Proof Spirits from 100lbs. in Gallons.	Quantity of Alcohol .825 in libs.		Quantity of of Extract in Pounds.	Quantity of Proof Spirits in Gallons per 100 lbs. of Extract.
Proof.	1 in 10 under.	1 to 10 over.	Proof.				Per Buſhel.	Per 100 lbs.		
16. 085	17. 874	2. 4369	2. 6809	2505. 054	41. 924	6. 38	11. 3983	27. 30	1631.	9. 862
16. 140	17. 936	2. 4453	2. 6901	2539. 625	42. 03	6. 355	11. 552	27. 10	1573. 753	10. 256
14. 241	15. 825	2. 1575	2. 3735	2465. 562	40. 99	5. 776	9 972	24. 32	1422. 024	10. 015
14. 177	15. 754	2. 1478	2. 3628	2509. 875	41. 801	5. 648	9. 902	23. 68	1436. 669	9. 868

ties.

14. 281	15. 869	2. 1636	2. 3802	2452. 375	40. 846	5. 823	10. 097	24. 72	1460. 434	9. 778
13. 905	15. 451	2. 1066	2. 3175	2375. 187	39. 48	5. 854	9. 900	25. 07	1447. 537	9. 599
13. 275	14. 752	2. 0113	2. 2126	2349. 875	39. 168	5. 649	9. 474	24. 19	1385. 385	

ities.

14. 893	16. 55	2. 2563	2. 4821	2303. 125	38. 433	6. 466	10. 719	27. 89	1359. 155	
14. 593	16. 216	2. 2108	2. 4322	2520. 50	41. 998	5. 789	10. 220	24. 33	1500. 696	9. 725

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

Column 1ſt exhibits the name and quality of the Grain and of the Malt employed in each Experiment. Here it is proper to remark, that, in the firſt ſuite of trials, the very ſame Grain was uſed in two ſucceſſive Brewings, and the ſame quality or rather denomination, for ſix. Throughout the ſeries of theſe ſix Brewings, it was the practice to make uſe of the third worts of one Brewing in the firſt maſh of the ſucceeding. Hence, inferences can only be drawn from the whole products of the ſeries.

Column 2d exhibits the weight per buſhel both of the Grain and Malt, aſcertained by weighing the whole of both, and dividing the total weight by the number of buſhels of each. No column is aſſigned to the quantity; becauſe in all the trials, that was the ſame, namely, 60 buſhels; and when a mixture of raw Grain and Malt was employed, it conſiſted of 40 buſhels of Grain and 20 of Malt. It is to be obſerved that, in the firſt ſuite, the produce of the two Brewings of the ſame Grain are exhibited together. The quantity is then double, viz. 60 buſhels for each Brewing; but this is always indicated by the number of Brewings ſtated in Column 3d.

Column 4th exhibits the quantity of waſh in wine gallons, determined by gauging the fermenting tun at the concluſion of the fermentation, and, of courſe, including the quantity of yeaſt.

In each compartment of column 5th there are two ſets of numbers, the upper gives the ſpecific gravity of the wort, and the under, of the waſh, by the ſaccharometer of Dr. Thomſon at temperature 60°. To read theſe numbers as real ſpecific gravities compared to water called 1000. prefix to each the figures 10. Thus the firſt in the column is 49.5. prefix 10 and the ſpecific gravity is 1049.5. It is proper to ſtate, that the original gravities of the worts could not always be accurately obtained; becauſe the fermentation had often begun in the wort of the firſt maſh before the others were added. Though therefore, the gravities of the recent worts cannot be perfectly accurate, yet we thought it worth while to inſert them, to ſhew nearly what they were.

Column 6th ſhews the quantity of Low Wines, or the produce of the firſt diſtillation of the waſh. It was found moſt convenient to diſtil the waſh of two Brewings without interruption; and the Low Wines therefore, are the return of the two Brewings exhibited together in the ſame line. Below the quantity in wine gallons, ſtands the ſtrength according to Dicas's hydrometer, which was more convenient in its application for the weak ſtrength than Clark's.

Column 7th exhibits the whole produce of ſpirit from "doubling" the Low Wines. It is ſubdivided into three parts. The firſt of theſe ſubdiviſions ſhews the quantity of ſpirit in gallons, collected in the general ſpirit-receiver, and indicated by the gauge. Below the quantity, and within the ſame compartment, are inſerted the temperature at which the gauge was taken, and the ſtrength, by Clarke's hydrometer, tried at temperature 64°. The ſecond and third diviſions exhibit the number of gallons which the ſpirit would meaſure at temperature 60° and reduced to the legal ſtrength of 1 to 10 *over*, and to the ſtrength of *proof*. The Tables of Mr. Gilpin furniſhed the data for calculating the deduction to be made on account of the heat, and the Exciſe Tables thoſe for reducing the ſpirits to the given ſtrengths.

Column 8th exhibits the quantity of ſpirit of the legal ſtrength of 1 to 10 *over*, and of the ſtrength of *proof*, produced by each quarter of Grain and Malt.

Column 9th the quantity of ſpirit obtained from each boll, of the three ſtrengths, the legal, proof, and diſtiller's ſale.

Column 10th the produce of ſpirit per buſhel. We have calculated theſe Columns, to exhibit the produce in all the different forms of expreſſion in common uſe.

Column

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

Column 11th exhibits the weight of the whole Grain and Malt of each ſeries, actually thrown into the maſh tun.

Column 12th the average weight of the mixed Grain and Malt per buſhel.

Column 13th the quantity of ſpirits at *proof*, yielded by 100 lbs. avoirdupois of the mixture of Grain and Malt, expreſſed in gallons. This was calculated to ſhew the difference of produce eſtimated from *weight* inſtead of *meaſure*.

Column 14th. As alcohol is the ſubſtance, the formation of which we were inveſtigating, and as the value of any ſpirit is denoted by the proportion of this body which it contains, this column exhibits the quantity of alcohol of the ſtandard ſtrength of .825, expreſſed in libs. avoirdupois, in its firſt diviſion, from each buſhel, and in the ſecond, from every 100 lbs. weight.

Three Suites of Experiments.

THESE Tables preſent a view of three ſeparate ſuites of trials, all of them, however, directed to the ſame object. The firſt and ſecond exhibit the Experiments with the mixture of raw Grain and Malt, in the proportion of two parts of the former, and one of the latter. The firſt comprehends the longeſt train of Experiments.

The number of the different kinds of Grain which we had to try was conſiderable. They were diſtributed according to their qualities. The ſuite is therefore ſubdivided into three parts; one part being allotted to each quality.

First Suite, Firſt Qualities.

Before commencing theſe ſeries of Experiments, ſeveral preliminary Brewings were practiſed, to ſeaſon the veſſels, and to put things into a proper train.* We began with Scotch Grain of the firſt quality. The Table exhibits the particulars of 4 Brewings only, with this denomination of Grain. In fact, 8 Brewings were performed; but in the firſt four, a larger quantity of Grain was maſhed, than well ſuited the ſize of the veſſels, and, of courſe, juſtice could hardly be done to it. Indeed, the product was ſomewhat ſhort of what it ought to have been. They are therefore omitted. The Scotch Barley was the produce of the Counties of Haddington and Linlithgow. The general characters of theſe Grains, and indeed of all the others, having been given formerly, need not be repeated. Their average weight was 51.47 libs. per buſhel, which is probably very near the average of the beſt Scotch Barley. The worts of the different Brewings did not ferment equally well; thoſe of the laſt, in particular, fermented ill. Some notion may be formed of the average ſucceſs of the fermentations of the whole ſeries from the ſubjoined view: but this and other views that follow to ſerve a like purpoſe, muſt not by any means be conſidered as perfectly exact. They are liable to inaccuracy, becauſe the original gravity of the worts could not be aſcertained with preciſion, as has already been particularly mentioned. We think, however, that the ſtatement of the original gravities muſt be ſo near the truth, as to make it worth while to draw up in this manner, a view of the comparative ſucceſs of the different fermentations.

To ſave repetition, it may be obſerved, that in all of them, Column 1ſt. exhibits the average of the original ſpecific gravities of the worts of each brewing of the ſeries; Column 2d. the average of the acquired attenuations; Column 3d. the average of the apparent attenuations; Column 4th the proportion which the average apparent attenuations bore to the average originals, ſpecific gravities ſtated in thouſandth parts, calling the original ſpecific gravity one thouſand. Had the original gravities of the worts been accurately determined, then the ſucceſs of the fermentations would have been directly in proportion to the numbers of this column, ſo far at leaſt as can be determined by the indications of the ſaccharometer; Column 5th. ſhews the average quantity of waſh; and Column 6th. the average produce of proof ſpirit, from each boll of the griſt.

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* This circumſtance accounts for the firſt Brewing in the Tables being called the thirteenth.

View

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

View of the Fermentation of Firſt Scotch Barley.

1.	2.	3.	4.	5.	6.
Original Specific Gravity of Worts.	Acquired Attenuation.	Apparent Attenuation.	Proportion of N° 3 to N° 1, called One Thouſand, in 1000th Parts.	Quantity of Waſh in Gallons.	Quantity of Proof Spirit in Gallons per Boll.
1059.9	1007.3	52.6	878	1209	14.58

The Engliſh Barleys of the firſt qualities were next ſubjected to trial. They were the growth of Suffolk, Kent, and Norfolk, and had an average weight of 50.75 libs. which is much below that of the beſt Engliſh Barleys in ordinary years. The worts alſo fermented ſomewhat unequally. The average reſults are as follow:

1.	2.	3.	4.	5.	6.
Original Specific Gravity.	Acquired Attenuation.	Apparent Attenuation.	Proportion of N° 3 to N° 1, in 1000th Parts.	Quantity of Waſh in Gallons.	Quantity of Proof Spirits in Gall^{s} per Boll.
1060.2	1006.6	54.2	900	1205.5	14,86

From this view, it is probable that the attenuations of this ſeries exceeded thoſe of the preceding: the quantity of ſpirit is ſomewhat greater.

The third ſeries of trials was allotted to Biggs of the firſt quality. Theſe came from the Counties of Lanark, Dumfries, Perth, and Aberdeen, and were uncommonly fine and heavy, weighing 49.27 libs. per buſhel. This weight is conſiderably greater than what has been generally aſſigned as that of the beſt quality of this ſpecies of Grain; and from the following view, it appears, that the worts from Bigg fermented as well as thoſe from Barley, and that the produce of ſpirits was very little inferior.

1.	2.	3.	4.	5.	6.
1055.6	1006.	49.6	892	1274.3	14.21

Barleys

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

Second Qualities.

Barleys of the ſecond quality came next in order, and the Scotch were tried firſt. They were the growth of the Counties of Perth, Angus, Fife, Linlithgow, and Edinburgh, having the average weight of 49.93 libs. per buſhel.

1.	2.	3.	4.	5.	6.
Original Specific Gravity.	Acquired Attenuation.	Apparent Attenuation.	Proportion of N° 3 to N° 1, in Thouſandth Parts.	Quantity of Waſh in Gallons.	Quantity of Proof Spirits in Gallons per Boll.
1055. 2	1005. 2	50	906	1243. 6	14. 17

The ſecond Engliſh Barleys were the growth of Suffolk and Kent, and weighed 49. 71 libs. per buſhel.

1.	2.	3.	4.	5.	6.
1049. 5	1007. 1	42. 4	856	1227. 1	12. 99

The produce of ſpirit is conſiderably leſs than any of the preceding. It is ſufficiently accounted for by the worts being weaker, and the fermentation leſs ſucceſsful. In the brewings of this Grain however, a ſmall miſtake was made which ought to be mentioned. The third worts of the ſixth and laſt brewing of the ſeries were inadvertently employed in the firſt maſh of the firſt Brewing of the ſucceeding one. Their place, however, was ſupplied by an equal value of worts from the third maſh of this next Brewing; ſo that the incident could have no ſenſible effect on the general reſult of the ſix trials. But to remove every doubt, and, at the ſame time, to examine, whether the more ſparing produce of ſpirit was owing to the nature of the Grain, or to the circumſtances of the operation, we thought proper to ſubject the ſame kind of Barley to a repetition of the Experiment. The following is the View of two Brewings:

1.	2.	3.	4.	5.	6.
Original Specific Gravity.	Acquired Attenuation.	Apparent Attenuation.	Proportion of N° 3 to N° 1, in Thouſandth Parts.	Quantity of Waſh in Gallons.	Quantity of Proof Spirit in Gallons per Boll.
1045. 95	1007. 5	38. 4	836	1483.	12. 50

The reſult of this repetition agrees pretty nearly with the former, though indeed the produce is a little leſs, and confirms the opinion that the fault lay in the Grain.

2. Report of Experiments on Malt made from Barley and Scotch Bigg.

The Biggs of the ſecond quality were the growth of the Counties of Mearns, Angus, and Dumfries. They were conſiderably heavier than *middling* Biggs uſually are, and were equal in this reſpect to the beſt Biggs of common years. Their weight was 48.43 libs. per buſhel.

1.	2.	3.	4.	5.	6.
1050.4	1002.8	47.6	944	1271.3	14.5

In this ſeries, all the fermentations were good; the average was better than any yet deſcribed, and the produce of ſpirit abundant Indeed, it was ſo large as to create an apprehenſion, that ſome overſight had been committed, though it is ſufficiently accounted for in the more complete attenuation of the worts. On repeating the trials, the produce was not ſo great, as appears from this ſketch:

1.	2.	3.	4.	5.	6.
1049.86	1004.8	45	903.6	1323	13.42

The inferiority of the produce of ſpirit is explained by the circumſtances of the parcel of Grain being lighter, and the attenuations not quite ſo good as in the firſt trials.

Third Qualities.

The third qualities of Grain came in courſe to be tried. For the Scotch Barley of this denomination, we took the lighteſt we had. It was from the Counties of Perth, Angus, Haddington, Berwick, and Linlithgow; but it was too heavy for a fair example of the pooreſt Scotch Barley, as it weighed 48.76 libs. per buſhel.

1.	2.	3.	4.	5.	6.
Original Specific Gravity.	Acquired Attenuation.	Apparent Attenuation.	Proportion of N° 3 to N° 1, in Thouſandth Parts.	Quantity of Waſh in Gallons.	Quantity of Proof Spirit in Gallons per Boll.
1053.7	1007.8	45.9	854.7	1214	13.27

The quantity of ſpirit from this Grain is rather ſmall. The fermentation had not advanced ſo well as uſual.

All the Engliſh Barley of this ſeries came from the County of Eſſex, having a weight of 48.22 libs. per buſhel.

1.	2.	3.	4.	5.	6.
1050.9	1006.6	44.3	870	1304	13.4

The attenuations were ſomewhat better than that of the third Scotch, and the produce of ſpirit a little larger.

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

To complete this part of the ſuite, we were at a loſs for Bigg of the worſt quality: the Experiments in the Breweries had conſumed all that had been procured of that deſcription. In fact, the unuſual fineneſs of the ſeaſon in Scotland, had made it rather a ſcarce article, and the quantity obtained for the Experiments was ſmall, though, as we learned from thoſe perſons who were employed by the Honourable Board, conſiderable pains were taken to procure in each Diſtrict all the different qualities. It had been reported to the Honourable Commiſſioners, that in Aberdeenſhire, and the other maritime northern Counties, a great deal of Bigg was raiſed on land manured by ſea ware, which Grain, in general, belonged to the loweſt ſtandard of quality, and it was ſuggeſted that, as a conſiderable part of the produce of thoſe Counties was of this deſcription, it would be right to include it in the inveſtigation. A Gentleman who poſſeſſes a large eſtate in one of the Counties, and who felt a particular intereſt in the queſtion under diſcuſſion, took the trouble of cauſing Bigg of this deſcription to be ſent for examination. To this Bigg, which bears the diſtinctive appellation of "Ware Bigg," we determined to reſort for the third ſeries of operations on this ſpecies of Grain. On weighing the different parcels, it appeared to be of very different qualities: a ſmall portion was ſo low as 45.47 libs. the greater came near to 49 libs. per buſhel: the average of the whole was 47.7 libs. From the manner of conducting our operations, we thought it beſt to compoſe one ſhorter ſeries of the Ware Bigg, with the view of aſcertaining its medium produce.

1.	2.	3.	4.	5.	6.
Original Specific Gravity	Acquired Attenuation.	Apparent Attenuation.	Proportion of N° 3 to N° 1, in Thouſandth Parts.	Quantity of Waſh in Gallons.	Quantity of Proof Spirits in Gallons per Boll.
1047.6	1004.9	42.9	901	1248.6	13.2

From this Table it appears, that the worts of the Bigg fermented as well as moſt of the others, and that the quantity of ſpirit was conſiderable.

We ſubjoin another ſhort View, exhibiting the average of all the preceding, omitting the repeated Experiments, and adding a ſeventh column, to ſhow the proportion which the bulk of the ſpirit bore to that of the waſh.

1.	2.	3.	4.	5.	6.	7.
Original Specific Gravity.	Acquired Attenuation.	Apparent Attenuation.	Proportion of N° 3 to N° 1, in Thouſandth Parts.	Quantity of Waſh in Gallons.	Quantity of Proof Spirits in Gallons per Boll.	Proportion of Proof Spirit in the Waſh.
1053.6	1006	47.9	889	1244.3	13.9	.1123

Second Suite: mixed Griſt.

The ſecond ſuite of Experiments which the Table N° XXV. preſents, conſiſted of ſingle Brewings of each quality of Grain. We wiſhed to try, whether the method we had followed of employing the worts of the third maſh of one Brewing, for the firſt maſh of the following, was as favourable for the production of ſpirit, as when each maſh was made with pure water. The Tables exhibit, with ſufficient minuteneſs, the circumſtances of each of theſe Brewings. We ſhall only obſerve, that of eight trials, five of the ſingle Brewings were

more

2. Report of Experiments on Malt made from Barley, and Scotch Bigg.

more productive, and three leſs ſo, than the average of the firſt ſeries. But as, under the ſame denomination, each variety of Grain and Malt was not in all the caſes the ſame as in the firſt ſuite, ſo ſmall a difference in the reſult does not warrant a concluſion in favour of unconnected Brewing. In this ſuite, the Engliſh Barley, uſed as an example of the ſecond quality, was the growth of Norfolk and Suffolk. It yielded 14,286 gallons of ſpirit, and regained the character which this denomination of Grain had loſt in the firſt trials.

Third Suite: Malt.

The third ſuite of Experiments comprehends thoſe in which Malt, without any admixture of raw Grain, was employed. It conſiſts of ſingle Brewings. In all of them, we had an opportunity of remarking the greater diſpoſition to fermentation, which the ſaccharine condition of the extract imparts. The fermentations, as was formerly mentioned, proceeded with greater activity, and the attenuations, as we ſhall now ſee, attained a greater pitch.

The ſhort Views, exhibiting the ſucceſs of the fermentations of the worts of the different Brewings, are thrown together in the following Table:

No.	Name of Grain from which the Malt was made.	Quality of Grain.	Weight of Malt per Buſhel.	Specific Gravity of Worts.	Acquired Attenuation	Apparent Attenuation	Proportion of apparent Attenuation to original Specific Gravity called 1000.	Quantity of Waſh in Gallons.	Quantity of Proof Spirit per Boll.
1.	Suffolk - - - - -	1ſt.	41.92	1026.8	1000.99	25.81	963	1922	16.085
2.	Suffolk and Kent - -	1ſt.	42.03	1038.6	1000.7	37.9	981	1458	16.14
3.	Haddington and Edinburgh - -	1ſt.	40.99	1051.2	1004.5	46.7	912	1201	14.241
4.	Bigg. Aberdeen - - - -	1ſt.	41.80	1048.5	1001.3	47.2	973	1364	14.177
5.	Kent - - - - - - -	2d.	40.84	1046.2	1000.	46.2	1000	1394	14.281
6.	Linlithgow - - - -	2d.	39.40	1041.5	1000.7	40.8	983	1505	13.905
7.	Bigg. Perth, Angus, Dumfries, and Aberdeen	2d.	39.16	1038.7	1000.7	38.4	992	1514	13.275
8.	Eſſex - - - - - - -	3d.	38.43	1034.8	1004.6	34.1	979	1588	14.893
9.	Berwick and Edinburgh	3d.	41.00	1039.7	1001.5	35.1	884	1417	14.593
10.	Average. Omitting Nº 1 - - -	—	40.61	1042.4	1001.6	40.8	963	1430	14.138

Proportion of Spirit to Waſh - 099

Nºs 1 and 2 preſent the Brewing, and produce of the ſame ſort of Malt, the firſt Engliſh; a ſecond trial having been made with this Malt, in conſequence of an overſight, fortunate in its reſult, committed in the firſt. The quantity of worts drawn was much larger than had been intended, or than could be contained in one fermenting tun. It was therefore deemed proper to repeat the Experiment, taking the ſame "lengths" as from the other Malts. This incident gave reaſon to believe that the quantity of ſpirit was not increaſed by uſing very weak worts; for the product of the ſecond trial exceeded the firſt. In both trials the produce of ſpirit was greater than had been yielded by the mixed griſt in any one caſe. This event was unexpected; as it is contrary to the opinion generally entertained, that raw Grain produces more ſpirit than Malt. The average reſult of all the Experiments concurs with the firſt one, and ſhews that, in our Experiments, the produce from Malt was greater than that from an equal meaſure of raw Grain and Malt. We have little heſitation

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

in aſcribing the ſuperiority in the preſent inſtance to the more fermentable nature of the extract from Malt, and the greater attenuations derived from it.

Taking the view of theſe attenuations as given in the Table, which it muſt be remembered are only approximations to the truth, it appears that, on the average of all the brewings of Malt, the proportion which the apparent attenuations bore to the original gravity, was as 963 to 1000, while the average of the apparent attenuations of the others, bore the proportion of 887 to 1000. We ſhall not pretend to ſay from theſe reſults, that Malt, in common, yields the greateſt quantity of ſpirit. Were the attenuation of the worts of raw Grain as perfect as thoſe of Malt, we have no doubt that they would yield moſt.

Proportion of Spirit to extract.

The Malt for theſe Experiments, we may conclude with again remarking, was always taken according to the original meaſure of it, and 60 buſhels were uſed, without any regard being paid to the quantity of the raw Grain to which they correſponded. Were the produce of the Malt to be eſtimated by the quantity of raw Grain from which it was made, the reſult would differ from what has now been ſtated, as will afterwards appear. In the part of the General Table, N° XXV, which includes theſe Experiments on Malt, two additional columns were added: the one to ſhew the total quantity of extract, which each of the ſixty buſhels of Malt, from the different kinds of Grain, yielded; and the other, to exhibit the quantity of proof ſpirit which was generated from every 100 libs. of the extract. The object was, principally, to examine, whether any difference of the extract, in reſpect to the proportion of ſpirit afforded by it, could be eſtabliſhed.

The Table indicates, that the ſame quantity of ſpirit was not afforded by the ſame quantity of extract preſent in the worts, in every caſe. It, at the ſame time, very decidedly ſhews, that the difference in the quantity of ſpirit was by no means conſiderable, and was equally great in the produce of different extracts, whether theſe had been obtained from Malt of the ſame, or of different deſcriptions. Thus, from every 100 libs of extract, contained in the worts from the Malt of Suffolk and Kent Barleys of firſt quality, on one occaſion, 10.256 gallons of proof ſpirits were obtained, and on another only 9.862 gallons; while the quantity from Aberdeen Bigg Malt was 9.868. Hence, we are diſpoſed to aſcribe the diſcordance, rather to ſome circumſtance of the proceſs itſelf, than to any diverſity of quality in the extract.

To complete this ſuite, a trial of Malt from Bigg of the third quality is wanting: there was none that could be reckoned of that deſcription.

To compreſs within a narrow compaſs a View of the products in theſe Diſtillery Experiments, we ſubjoin the following Tables, namely, N^os XXVII. XXVIII. and XXIX.

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Report of Experiments on Malt made from Barley and Scotch Bigg.

Produce of ſpirit in firſt two ſuites.

TABLE XXVII.

VIEW of the Quantity of SPIRIT obtained from BARLEY and BIGG, in the two firſt Suites of Experiment.

Engliſh Barley.

1.		2.			3.			4.
Quality of Grain.	Number of Brewings, of which the Average is given.	Quantity of Proof Spirits, in Galls per Quarter.			Quantity of Proof Spirits per Boll.			Proportion in 100 Parts.
		Produce in Firſt and Second Suites.	Average of each Quality.	Average of Three Qualities.	Produce in Firſt and Second Suites.	Average of each Quality.	Average of Three Qualities.	
1.	Six - - -	19.817	18.798	18.326	14.863	14.098	13.744	100.
	Single - -	17.779			13.334			
2.	Six - - -	17.319	18.183		12.989	13.637		
	Single - -	19.048			14.286			
3.	Six - - -	17.874	17.997		13.405	13.498		
	Single - -	18.121			13.591			
Scotch Barley.								
1.	Four - - -	19.447	19.039	18.796	14.585	14.279	14.097	102.568
	Single - -	18.631			13.973			
2.	Six - - -	18.899	18.934		14.174	14.200		
	Single - -	18.969			14.226			
3.	Six - - -	17.70	18.416		13.275	13.812		
	Single - -	19.132			14.349			
Scotch Bigg.								
1.	Six - - -	18.952	19.039	18.534	14.214	14.279	13.900	101.135
	Single - -	19.126			14.344			
2.	Six - - -	19.337	18.832		14.503	14.124		
	Single - -	18.327			13.745			
3.	Four - - -	17.732 =	17.732		13.299 =	13.299		

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Report of Experiments on Malt made from Barley and Scotch Bigg

TABLE XXVIII.

Shewing the Quantity, in Libs. Avoirdupois, of ALCOHOL of the Strength .825, obtained from the different Grains in the two firſt Suites of Experiment.

English Barley.

1.	2.	3.			
Quality of Grain.	Nº of Brewings.	Libs. of Alcohol .825 per Buſhel.			Proportion in 100 Parts.
		Produce of Firſt and Second Suite.	Average of each Quality.	Average of Three Qualities.	
1.	Six - - - - -	10.348	9.9495	9.6548	100.
	Single - - - -	9.551			
2.	Six - - - - -	9.0813	9.5481		
	Single - - - -	10.015			
3.	Six - - - - -	9.355	9.467		
	Single - - - -	9.579			

Scotch Barley.

1.	2.	3.			
1.	Four - - - - -	10.3159	10.0264	9.8647	102.17
	Single - - - - -	9.737			
2.	Six - - - - -	9.969	9.9405		
	Single - - - -	9.912			
3.	Six - - - - - -	9.2639	9.6274		
	Single - - - - -	9.991			

Bigg.

1.	2.	3.			
1.	Six - - - - -	10.045	9.9645	9.77303	101.22
	Single - - - - -	9.884			
2.	Six - - - - -	10.1445	9.8957		
	Single - - - -	9.649			
3.	Four - - - - -	9.4579 =	9.4579		

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

The firſt Table is intended to exhibit the quantity of proof ſpirit obtained in the firſt two ſuites of our Experiments, from each quarter and boll of Barley and Bigg. It is divided into three parts. The firſt includes Engliſh Barley; the ſecond, Scotch Barley; and the third, Bigg. In each of them, column 1ſt denotes the quality of the Grain, and column 2d the number of Brewings, in each ſuite, employed to obtain the average reſults ſtated in columns 3d and 4th.

Column 3d contains three diviſions. The firſt exhibits the produce of proof ſpirit per quarter, from each quality of Grain in the two ſuites. The ſecond, the average of theſe; and the third, the average produce of the three qualities of Grain per quarter.

Column 4th. gives a view of the ſame, eſtimated per boll. From this Table it appears, that the average produce of twenty one brewings of Engliſh Barley, including the three qualities, was 13.744 gallons per boll; of nineteen brewings of Scotch, 14.097; and of eighteen of Bigg, 13.9 which may be ſtated thus:

Engliſh	100
Scotch	102. 568
Bigg	101. 135.

The relative produce of theſe different ſorts of Grain was altogether unexpected, and ſhall be conſidered hereafter. Having aſcertained the quantity of alcohol obtained in each Diſtillation, in the manner formerly deſcribed, we ſhall ſubjoin a Table exhibiting the proportion of this ſubſtance yielded by the different ſorts of Grain, partly with the deſign of ſhewing how nearly the reſults in the one mode of eſtimating agree with thoſe in the other. One of our number examined the produce in this manner, while another aſcertained it by the legal hydrometer of Clarke. The coincidence was gratifying, as it demonſtrated the accuracy of both. This Table, N° 28, will be at once underſtood, from what has been ſaid of the former.

Calling the quantity of alcohol, from the Engliſh Barley - 100.
that from the Scotch, is - - - 102.173
and that from the Bigg, - - - 101.224

The difference between this and the preceding View does not amount to $\frac{1}{100}$th part.

Produce in third ſuite.

The 3d ſuite of Experiments, in which equal meaſures of pure Malt were uſed, furniſhes a reſult very different from the two former.

TABLE XXIX.

Kind of Grain.	Quantity of Proof Spirit.		Proportion. in 100 Parts.
	Per Quarter.	Per Boll.	
Average from Engliſh Grain, 3 qualities - - - - -	20. 139	15. 104	100.
Average from Scotch Grain, 3 qualities - - - - -	18. 995	14. 579	96. 52
Average from Bigg, 2 qualities - - - - - - - - -	18. 301	13. 726	90. 87

This View ſhews that the produce of the Malt from Engliſh Grain, exceeded that from Scotch Barley by 3½ per cent. and that from Bigg, by 9.13 per cent.

The difference between theſe reſults, and thoſe afforded by the mixture of raw Grain and Malt, is very conſiderable; and in all probability, it would have been ſtill greater in the caſe of the Bigg, had a brewing of Malt from this Grain of the third quality taken place.

In all our Experiments, equal meaſures of the different articles were employed, and the products bear relation to them. We have, however, alſo calculated the products by the *weight* of the materials, of which a View is given in the two following Tables.

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Report of Experiments on Malt made from Barley and Scotch Bigg.

Produce eſtimated by weight.

TABLES,

Shewing the Proportion of Spirit produced from equal Weights of mixed Raw Grain and Malt, ſtated in 100 Parts.

TABLE XXX.

1. Shews the Produce of the firſt Suite.

Quality of Grain.	Engliſh Barley.	Scotch Barley.	Biggs.
1.	100.	98. 151	98. 278
2.	90.0208	94. 1636	100. 985
3.	94. 283	91.4624	95. 734

2. Shews the Produce in the 2d Suite, or ſingle Brewing.

1.	90. 1685	92. 6614	99. 7347
2.	97. 7836	97. 6889	94. 999
3.	94. 1845	97. 8594	00.
Average of whole	94. 4068	95. 3314	97. 9461
Stated per cent.	100.	100. 979	103. 748

TABLE XXXI.

Shewing the Proportion of Spirits produced from equal Weight in Malt, in 100 Parts.

1.	100.	90. 5329	88. 5266
2.	91. 2695	91. 7554	88. 5423
3.	101. 3479	90. 7366	—
Average - -	97. 539	91. 0083	88. 5344
Stated per cent.	100.	93. 3055	90. 7692

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

The firſt of theſe, N° XXX. is divided into two parts; the one ſhewing the proportion of ſpirit produced from equal weights of the mixture of raw Grain and Malt, in the firſt ſuite; and the other, the proportion in the ſecond. In each, Column 1ſt. indicates the quality of the Grain. Column 2d. the proportion of ſpirit, which the different qualities of Engliſh Grain produced; and, calling that from the firſt Engliſh 100, it exhibits the proportions which the others bore to it. Column 3d, ſhews the proportional produce of the Scotch Grain of different qualities; and Column 4th. that of Bigg.

The general reſult of the whole is, that, if the produce from a given weight of the Engliſh Grain, uſed in the trials, be called 100, that of Scotch

is - - - - 100.979

and of Bigg, - 103.748

The next Table, N° XXXI. exhibits the produce from Malt calculated in the ſame manner, ſtating the average of

3 Brewings of Malt from Engliſh Grain, - - - 100.
3 Ditto - - - - - Scotch Grain - - - 93.305
2 Ditto - - - - - - - Bigg - - - - 90.769

In this mode of eſtimating the produce, nearly the ſame ſuperiority of the Malt from Barley over that from Bigg appears, as in calculating by meaſure.

Before concluding this account of the diſtillery operations, we beg leave to obſerve, that the quantity of ſpirit obtained in them, gives us reaſon to hope that they were managed with conſiderable ſkill and attention; though we are far from thinking that the produce is as large as it is poſſible to procure from Grain, ſimilar to what was tried. From the ſtatements given in the Reports concerning the Scotch Diſtillery, printed by order of the Houſe of Commons in 1799, the average produce from a boll of a mixture of two parts of raw Grain and one of Malt, ought to be rated at 11.6 gallons of proof ſpirit. In our trials, the average produce of the whole Grain, both Barley and Bigg, was - - - - - 13.91 gallons of proof.

equivalent to 12.63 — 1 to 10 over,

or 15.44 — 1 in 10 under.

In the ſame Report, Malt, at an average, is ſtated to afford 9.95 gallons of proof ſpirit per boll. The average of the above deſcribed trials was

14.469 at proof,

or 13.138 at 1 to 10 over,

or 16.06 at 1 in 10 under.

In theſe Statements, we believe, we have followed the common practice of Diſtillers, in making no allowance for that trifling portion of ſpirits which the yeaſt may have furniſhed.

CONCLUSION.

CONCLUSION.

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

HAVING finiſhed the detail of the two ſets of Experiments, by which we propoſed to inveſtigate the relative qualities and value of the different ſorts of Malt from Barley and Bigg, we ſhall now bring into one view the reſults of both, that we may compare them together and draw the neceſſary concluſions. The one ſet of Experiments was made in the Brewery; the other, in the Diſtillery. In the former, we endeavoured to eſtimate the values by the quantity of extract, or ſaccharine matter, which the Malts reſpectively yielded; in the latter, by the quantity of ſpirits. Before drawing any concluſions, regarding the matter of enquiry, from theſe Experiments, we think it neceſſary again to call the attention of the Honourable Board to the numberleſs difficulties that occur in obtaining preciſe and accurate reſults. Many of them, before beginning our trials, we were led to expect; but, in proſecuting the reſearch, we have experienced them to a degree of which we were little aware. They ariſe from various ſources, and are inſeparable from an inveſtigation of this nature. We allude to them now, as they lead us to remark, that, with all the pains and attention that have been given to every part of this buſineſs, we can only preſume to offer the individual reſults as approximations to truth. The general reſults, being the mean of the averages of two very extenſive courſes of Experiments, are, we hope, entitled to greater confidence. Theſe we ſhall now proceed to ſtate and to compare. Though the queſtion at preſent relates ſolely to the comparative values of Malt made from the two diſtinct ſpecies of Grain, Barley and Bigg, ſtill we ſhall in our ſtatement preſerve ſeparate the view of the qualities of the Malt made from Barley of the growth of England, and of the growth of Scotland, as we have hitherto done by the direction of the Honourable Board.

As Grain is ſold by meaſure, and as the Duty on Malt is levied in the ſame manner, it will be proper that we follow the ſame plan, and compare the produce of equal meaſures of the different articles. That the comparative view of the relative values may be as full as poſſible, the compariſon may be inſtituted three different ways, each of which will be found to give a different reſult. We may compare, 1ſt. the produce or value of equal meaſures of raw Grain. 2d. That of equal meaſures of Malt; and 3d. that of equal meaſures of raw Grain when converted into Malt. Theſe we ſhall diſtinguiſh by the following titles:

I. VALUE OF RAW GRAIN.

II. VALUE OF MALT.

III. VALUE OF RAW GRAIN MALTED.

I. VALUE OF RAW GRAIN.

Value of raw Grain.

Though the immediate object of the whole reſearch is the relative values of Malt, yet it appears to be of great conſequence to aſcertain the comparative value of the different ſpecies of Grain in their raw ſtate, as it would determine the important queſtions, whether Bigg is a ſpecies of Grain in its nature inferior to Barley, and whether any inferiority that may appear in Malt made from the former, ariſes from the mode and effect of malting, or from the quality of the Grain itſelf.

None of the Experiments however, above detailed, furniſh means of aſcertaining, with abſolute preciſion, the relative values of the raw Grain; but one part of the Experiments by Diſtillation enables us to diſcover them pretty nearly. We mean thoſe Experiments, in which the large proportion of two parts of raw Grain to one of Malt was uſed with the view of avoiding, as far as poſſible, the perplexity and uncertainties occaſioned by the different methods of making Malt. Before mentioning theſe, it may be worth while to exhibit the

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the View formerly given of the average weights of the different ſpecies of Grain ſubmitted to Experiment. They are the following:

	Average Weight of Grain per Buſhel in lbs. Avoirdupois.	Proportion.
Engliſh Barley - - -	49.872	100.0
Scotch Barley - -	49.754	99.763
Scotch Bigg - - - -	47.352	94.94

The proportion of ſpirit which equal meaſures of theſe different Grains, when mixed with half the quantity of their own Malt, produced in the proceſs of Diſtillation, is ſhewn in the following Table. The ſpirit is ſtated at the ſtrength of proof, and the quantity calculated by the meaſure of one boll of ſix buſhels.

	Quantity of Proof Spirits per Boll in Gallons.	Proportion.
Engliſh Barley - - -	13.744	100
Scotch Barley - - -	14.097	102.568
Scotch Bigg - - -	13.9	101.135

Theſe numbers do not, however, exactly repreſent the values of the raw Grain; becauſe one-third part was Malt, of which, in our trials, the produce is not quite the ſame with that of raw Grain.

Were we entitled to conclude, what ſurely we are not, that Malt, when mixed with double its quantity of raw Grain, always furniſhes juſt as much ſpirit as when uſed alone, we could aſcertain ſtill more nearly the actual produce of the Grain: for this purpoſe, it would only be neceſſary to ſubtract the proportion found by other Experiments to be due to the Malt, and the remainder would repreſent the produce of the raw Grain. Were the eſtimate to be made after this manner, it would increaſe the produce of the Grain of Scotland, both Barley and Bigg, beyond what is above ſtated: becauſe the Malt of Engliſh Barley was conſiderably more productive than either of the others.

Satisfied, however, that this would not be a fair method, we muſt abide by the approximation furniſhed by the mixture: and as ſubtracting the produce of the Malt would lower the value of the Engliſh Barley more than either that of Scotch Barley or Bigg, we may confidently conclude, that the number in the preceding Table, expreſſing the values of the Scotch Barley and Bigg, are rather below than above the truth. Thus the greateſt average values of the Barley uſed in our trials, rated by the quantity of ſpirit, is 1.4 per cent. greater than that of Bigg: but the Engliſh Barley proved 2.5 per cent. inferior to the Scotch, and 1.1 per cent. inferior even to the Bigg.

We confeſs that this reſult excited a conſiderable degree of ſurprize. We had by no means expected that the Bigg would yield a quantity of ſpirit ſo little inferior to the Barley, and far leſs that that quantity would prove larger than the produce of Engliſh Barley. A reſult ſo unexpected deſerves to be particularly conſidered. No concluſions are to be drawn from it, unleſs all the circumſtances of the Experiments ſhall be taken into account. Some of theſe muſt now be ſtated, as they ſerve in a great meaſure to explain it.

1. The

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Cauſe of ſmall produce of ſpirits from Engliſh Barley.

1. The Engliſh Barley, of all the three qualities, was greatly inferior to what it is in ordinary years. 2. The Bigg of the ſame qualities was in a ſtill greater degree better than uſual. 3. The Bigg which was uſed under the denominations of ſecond and third qualities, was conſiderably above the averages of theſe denominations, and approached too cloſely to the firſt quality. This circumſtance ſeems to have ariſen from the fineneſs of the ſeaſon in Scotland, which diminiſhed vaſtly the diſparity uſual among the different qualities of this Grain. 4. The ſecond quality of the Engliſh Barley was peculiarly unproductive, owing, in all probability, to ſomething connected with the individual parcel of Grain employed. This accidental deficiency, however, contributed to lower conſiderably the average produce of the whole Engliſh Barley, and cauſed that deſcription of Grain to appear worſe than it really was.

From this ſtatement, it will appear prudent not to draw a concluſion diſadvantageous to the Engliſh Grain, nor too favourable for the Bigg, while there can be no heſitation in admitting the inference, that the latter, when raiſed in a good ſeaſon and ſituation, contains fermentible matter capable of yielding a large produce of ſpirit, and is therefore a ſpecies of Corn that ought not to be accounted of ſo inferior a deſcription as by many perſons it has been.

II. VALUE OF MALT.

Value of Malt.

The relative values of the Malts were examined in two ways, 1. by the quantity of extract which, in equal meaſures, they yielded in Brewing; and 2. by the quantity of ſpirit in Diſtillation. This Table exhibits the abſolute and relative produce obtained in both methods:

	Quantity of Extract per Buſhel in lbs. Avoirdupois.	Proportion.	Quantity of Proof Spirit per Boll.	Proportion.
Engliſh Barley - - -	22. 212	100.	15. 104	100.
Scotch Barley - - -	22. 803	102. 66	14. 579	96. 52
Scotch Bigg - - -	21. 305	95. 915	13. 726	90. 87

It appears from the firſt part of this Table, which, it may be obſerved, contains the average of 50 trials, that in the brewing Experiments Malt from Bigg afforded nearly 7 (6.8) per cent. leſs extract than the Malt from Scotch Barley, with which it is here compared; becauſe the latter yielded the beſt produce, and nearly 2.6 per cent. more than the Malt from the Engliſh Grain. The ſecond part of this Table ſhews, that Bigg Malt produced 9 per cent. leſs ſpirit than the Engliſh Barley Malt, with which it is now compared, as the Engliſh yielded 3½ per cent. more than the Scotch.

We think it right again to mention, that the ſtate of the produce of Malt, in Diſtillation, is taken from ſingle trials of the different qualities of Malt, and does not include, for the reaſons already aſſigned, a trial of the third quality of Bigg. Theſe trials with Malt in Diſtillation were leſs numerous than they ought to have been, or indeed would have been, could we have foreſeen that the relative proportions in the produce from the different ſorts of Grain, in their raw ſtate, and when malted, were to differ ſo greatly. Being influenced by the general opinion, we rather gave the preference to the Experiments with raw Grain, in order to avoid the uncertainty ariſing from the variable quality of Malt.

The relative values however, eſtimated in both ways, do not differ much from each other, when the compariſon is made with the beſt average, whether furniſhed by Engliſh or Scotch Barley. When the average is ſtruck upon this principle, between the reſults of the two ſets of Experiments, it will be ſeen from the following view, that Bigg Malt yielded 8 per cent. leſs produce than Barley Malt.

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		Mean.	Proportion.
Scotch Barley in Brewing - - - -	102. 66	101. 33	100.
Engliſh D° in Diſtilling - - - - -	100.		
Bigg in Brewery - - - - - - - -	95.91	93. 39	92. 16
D° in Diſtillery - - - - - - - - -	90.87		

Though we conſider this as the fair mode, we ſhall add a View of the relative produce, when the compariſon is drawn between Bigg Malt and the average of the Engliſh and Scotch Barley Malt.

				Mean.	Mean.	Proportion.
Barley Malt.	Brewery	Engliſh	100	101. 33	99 .79	100
		Scotch	102. 66			
	Diſtillery	Engliſh	100	98. 26		
		Scotch	96. 52			
Bigg Malt	Brewery - - -		95. 91	- -	93. 39	93. 58
	Diſtillery - -		90. 89			

Difference in proportion of ſpirit from raw Grain and Malt.

In this caſe the produce of the Bigg Malt is 6½ per cent. inferior to that of Barley Malt. Either ſtatement, but particularly the former, differs much from the preceding one, deduced from the Experiments in which a proportion of raw Grain was employed. The difference is ſo remarkable, and the inferiority of the Bigg Malt ſo conſiderable, as to render it proper for us to ſtate our opinion of the probable cauſes of it. The difference in the relative produce of Bigg and Barley, when tried in their raw ſtate, and when malted, may be occaſioned either by the mode of carrying on the proceſs of malting, or by Barley eſſentially ſtanding the operation of malting better, and affording neceſſarily a better Malt. Both of theſe circumſtances, we are of opinion, have concurred to produce the effect. 1. Bigg, being a ſmall Grain, appears to require much attention and ſome difference of management in malting. Our Maltſters were unfortunately not well acquainted with its peculiarities, and could hardly do it juſtice. In particular, we believe that it was allowed to remain too long both in the ſteep and on the floor. 2. Barley is generally believed to bear the operation of malting in a material degree better than Bigg, and to yield a Malt of ſuperior value. From our Experiments we are led to believe that this may be the caſe, and that this cauſe has a ſhare in producing the remarkable difference.

Another circumſtance exhibited in the Table calls likewiſe for explanation, namely, the difference in the produce of the Engliſh and Scotch Barley in the two courſes of Experiment. In the Brewing, the different parcels of Scotch Grain under trial yielded more extract than the Engliſh; but in the Diſtillery, the latter furniſhed more ſpirit, from which diſcrepancy one might be apt, at firſt, to conclude, that theſe two modes of inveſtigating their relative qualities and value do not correſpond with each other, and that the proportion of extract is not a correct criterion of the proportion of ſpirit. But this concluſion will appear to be premature, for the principal cauſe was a real difference in the relative qualities of the different parcels of the Malt uſed, though under the ſame denomination, in the ſeveral proceſſes. The Scotch Grain of the firſt qualities, for example, malted for Brewing, was conſiderably heavier than that which remained for the Diſtillery Experiments; and, on the other hand, the firſt Engliſh Barley malted for Diſtillation, exceeded the average of the ſame deſcription of Grain employed in Brewing. This difference, it may be added, clearly appears from the circumſtance, that the Engliſh Malt, in the diſtillery courſe, did actually yield more extract than the Scotch, though not in a proportion equal to that of the ſpirits.

Variations alſo accidental in the proceſs of malting, or in the operations of Brewing and Diſtilling, may perhaps, help to account for the whole diſcordance, without ſuppoſing any actual difference in the quality of the extract. For howſoever much extract may differ on other occaſions, we cannot ſay that any ſtriking diſparity was obſerved by us.

An examination of the two preceding Views ſhews that the produce of ſpirit from Malt alone, exceeded that from equal meaſures of the mixture of raw Grain and Malt by four per cent. This circumſtance we have already aſcribed to the more thorough attenuation of the wort from the former.

2.
Report of Experiments on Malt made from Barley and Scotch Bigg.

Value of raw Grain malted.

III. VALUE OF RAW GRAIN MALTED.

If equal meaſures of raw Grain undergo the proceſs of malting, they will produce a greater or leſs bulk of Malt according to the quality of the Grain and the ſkill of the Maltman. The value of the raw Grain malted is diſcovered, by taking the Malt ariſing from a given meaſure of Grain, whatever its bulk may be, and aſcertaining the produce of that Malt. The following Table, though formerly given, may be again inſerted, to ſhew the relative average quantities of Malt which were obtained from the different ſorts of Grain.

	Quantity of Malt from 100 Buſhels raw Grain.	Proportion.
Engliſh Barley - - -	105. 5	100.
Scotch Barley - - -	99. 3	94. 123
Scotch Bigg - - -	99.	93. 838

If we now ſtate the produce of the Malt, both in Brewing and Diſtilling, from equal meaſures of raw Grain, the reſult will be as follows:

	Quantity of Extract in lbs. from one Buſhel of raw Grain made into Malt.	Proportion.	Quantity of Proof Spirit from one Boll of raw Grain made into Malt.	Proportion.	Mean.
Engliſh Barley - - -	23. 545	100.	15. 954	100.	100.
Scotch Barley - - -	23. 026	97. 795	14. 480	90. 76	94. 27
Scotch Bigg - - -	20. 914	88. 825	13. 158	82. 47	85. 64

The remarkable difference which ſubſiſts between the reſults here ſtated and the foregoing, ariſes obviouſly, from the Engliſh Grain yielding a greater bulk of Malt than either the Scotch Barley or Bigg:—and, thus eſtimated, the produce of raw Bigg, when malted, is 14.5 per cent. leſs than that of Engliſh Barley malted, and about 12 per cent. inferior to that of the average of the Engliſh and Scotch Barley.

Thus, we have exhibited three very different Views of the relative produce and values of Barley and Bigg, which, on contraſting the Bigg with the beſt average of Barley, may be ſtated thus:

	Relative Values eſtimated by		
	1. Raw Grain.	2. Malt.	3. Raw Grain Malted.
Barley - - - - -	100.	100	100
Bigg - - - - - -	98. 6	92. 16	85. 6

2. Report of Experiments on Malt made from Barley and Scotch Bigg.

The values eſtimated in theſe three ways, differ widely from each other. We have, therefore, now to conſider, which of them ought to be adopted as moſt nearly exhibiting the relative qualities and values of Malt made from Barley and from Scotch Bigg; the object of the whole inquiry. Upon this point we have no doubt. It is obvious, that the firſt of them, taken from the produce of raw Grain, muſt be rejected, though at one time we thought otherwiſe. It appears to us equally clear, that the ſecond value, eſtimated from the produce of equal meaſures of Malt, ought to be preferred. Though we adopt this ſtate of the relative values, we conſider the others to be of conſiderable importance. The firſt will probably ſecure a favourable opinion of the value of ſuch Bigg as we tried, when employed in a raw ſtate to yield ſpirits, and the third furniſhes the rule by which one ſhould judge of the value of different ſpecies of Grain for malting, or in purchaſing Grain for that purpoſe. Perhaps ſome perſons may even give it the preference in eſtimating the value of Malt, as it is free from one great ſource of uncertainty, the variable quantity of Malt from a given meaſure of Grain. But as the queſtion at preſent under diſcuſſion, relates to the Duties payable on Malt, and as theſe Duties are levied without any reference to the raw Grain, upon the meaſures of Malt produced, as nearly at leaſt as the eſtabliſhed mode of determining the quantity permits, we neceſſarily muſt abide by the ſecond mode, and eſtimate the relative values by comparing the produce of equal meaſures of that article.

General Reſult.

The general reſult of our Experiments may therefore be ſtated thus: Malt made from Bigg the growth of 1804, was eight per cent. leſs productive than Malt made from Barley grown in the ſame year.

We have now ſubmitted to the Honourable Board the reſult of our inveſtigations, and would hope, that our ſtatements will enable them to reply to the queſtions propoſed by the Lord Commiſſioners of His Majeſty's Treaſury, reſpecting the propoſed reduction of the Duty on Malt made from Scotch Bigg. We beg leave, however, to ſubjoin two remarks. The concluſions reſpecting the comparative values, are only applicable, when the different ſpecies of Grain poſſeſs the ſame relative qualities as thoſe employed in our Experiments, and, as the relative qualities and value of the Grain uſed in our trials were very different from thoſe of the ſame ſpecies in common ſeaſons, the Engliſh Barley being much worſe, and the Scotch Bigg much better than uſual, the reſults afforded by theſe Experiments, made on the produce of 1804, cannot, with juſtice, be applied to that of ordinary years.

THO^s CHA^s HOPE.
A. COVENTRY.

3.
Concluſion,
by Dr. Thomſon.

CONCLUSION, by Dr. THOMSON.

IT will now be proper to collect, under one view, the general reſults of the whole Experiments, in order to obtain as correct an eſtimate as poſſible of the relative values of the Barley and Bigg which formed the ſubject of inveſtigation.

The *weights* of the *raw Grain* and *Malt* have been given in the firſt and ſecond parts of the preceding Report; while the produce of each in *extract* or in *ſpirits* has been ſtated in the third and fourth parts. Theſe numbers furniſh the data upon which the concluſions muſt be founded. In comparing them together, it will be convenient to aſſume 100 as the *conſtant value* of the Engliſh Grain or Malt, and to ſubſtitute for the value of the other kinds of Grain, numbers bearing the ſame relation to 100, as thoſe in the preceding Tables do to each other; or, in other words, to ſubſtitute for the *abſolute values* ſtated in the preceding Tables, the equivalent *values* per cent.

As Grain is purchaſed at preſent by bulk, and not by *weight*, and as the ſame practice is followed in levying the Duty upon Malt—it will be neceſſary to compare together *equal bulks* of the different kinds of Grain and Malt, and draw the concluſions accordingly, even though this were not the beſt mode of aſcertaining the real values of each. Now this compariſon may be made in three different ways: we may compare together *equal bulks* of the different kinds of Grain in the raw ſtate; or, we may take *equal bulks* of each, convert them into Malt, and eſtimate the relative values of this *Malt*; or, finally, we may contraſt the produce of *equal bulks of Malt*, without any regard to the bulk of the raw Grain from which it was produced. Theſe three modes of compariſon may be diſtinguiſhed by the following names:

I. VALUE OF THE RAW GRAIN.

II. VALUE OF THE RAW GRAIN MALTED.

III. VALUE OF THE MALT.

I ſhall ſtate in ſucceſſion the reſult afforded by each.

I.

VALUE OF THE RAW GRAIN.

Though Malt alone was the primary object of inveſtigation, yet it was of importance to eſtimate the relative values of the Barley and Bigg in the raw ſtate. Suppoſing theſe values known, it would be eaſy to decide whether the one ſpecies of Grain be really inferior to the other, as has been conſtantly affirmed; or whether the alledged inferiority be owing to the proceſs of malting, or to the ignorance or inattention of the Maltſters. Now raw Grain may be employed for Diſtillation mixed with a ſmall proportion only of Malt. Hence we have a method of ſolving the problem in queſtion. Above ſixty Brewings were made from a mixture of raw Grain and Malt, as has been detailed at length in the preceding Report. The following Table exhibits the relative values of Engliſh Barley, Scotch Barley, and Bigg, reſulting from theſe trials; ſuppoſing theſe values to be meaſured by the quantity of alcohol obtained from each kind of Grain, and the alcohol from Engliſh Barley to be called 100.

	Values.
Engliſh Barley - - -	100.
Scotch Barley - - -	102.
Scotch Bigg - - -	101.

3. Concluſion, by Dr. Thomſon.

Or the Scotch Barley employed in our Experiments was two per cent. and the Bigg one per cent. *better* than the Engliſh Barley. This reſult, ſo different from the generally received opinions, was quite unexpected. But as the trials were carefully made, and were ſufficiently numerous to obviate the effects of accidental anomalies, it will be neceſſary to abide by it.

It muſt be remarked, however, that the numbers given in the preceding Table do not exhibit the true values of the three kinds of Grain under compariſon. They are the reſult of trials on mixtures of 40 buſhels of raw Grain and 20 buſhels of Malt. By ſubſequent Experiments, it was aſcertained how much alcohol 20 buſhels of Malt from each kind of Grain are capable of yielding. If this quantity be ſubtracted from the whole alcohol produced by the 60 buſhels of the *mixture*, the remainder ought to correſpond with the alcohol furniſhed by the 40 buſhels of raw Grain, and this number divided by 40, ought to be equivalent to the alcohol from a ſingle buſhel. Hence we obtain the value of a buſhel of *raw Grain*, without any mixture of Malt. The following Table exhibits this value, ſuppoſing, as before, the alcohol from Engliſh Barley to be repreſented by 100.*

	Values.
Engliſh Barley - - -	100.
Scotch Barley - - -	107
Bigg - - - - - - -	108

Or the Scotch Barley was 7 and the Bigg 8 per cent. better, than the ſame bulk of Engliſh Barley.

In operations of ſo very complicated a nature, as thoſe deſcribed in the preceding Report, the reſults ought to be ſtated with the greateſt caution. However, if any confidence is to be put in the Experiments above detailed, this Table muſt be conſidered as a much nearer approximation to the real value of the raw Grain than the preceding, which gives only the value of a mixture of raw Grain and Malt.

Various circumſtances, doubtleſs, contributed to produce this very unexpected reſult. One or two of theſe may be mentioned.

1. It is well known that the ſummer of 1804, in which all the parcels of Grain ſubjected to Experiment, had been raiſed, was one of the beſt ever remembered in Scotland; while in England, on the contrary, it was uncommonly bad. Hence all the Scotch ſamples of Barley and Bigg were not only greatly above the average of ordinary years; but there was really no inferior Grain to be procured. What we uſed as *ſecond* and *third* qualities, would probably in common ſeaſons have paſſed for *firſt* qualities. The very reverſe was the caſe with the Engliſh Grain, which was not only under the average, but probably the difference between the three qualities of it was greater than uſual.

2. When ground Malt and water are infuſed together, the wort runs off without difficulty from the mixture, and, by repeated maſhings, the Malt may be completely drained of its ſoluble matter. But when raw Grain is employed, the wort has but little diſpoſition to run off. Indeed, the Diſtillers frequently mix the *ſeeds* or *huſks* of *oats* with their maſh, to facilitate the ſeparation of the wort. Now as in our trials no ſuch foreign ſubſtance was uſed, it is poſſible that the wort may have run off moſt freely from thoſe maſhes which contained the greateſt proportion of huſk. But as in Bigg the huſk bears a much greater proportion to the whole Grain than in Barley, it is conceivable that it may yield better to water than Barley while in the ſtate of raw Grain, independent of any greater proportion of ſoluble matter which it may contain.

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* See Appendix, Number I.

3.
Concluſion,
by Dr. Thomſon.

II.

VALUE OF RAW GRAIN MALTED.

The ſecond mode of eſtimating the value of the different kinds of Grain is by taking *equal bulks* of each, converting them into Malt, and comparing the produce yielded by that Malt.

Now as Malt may be employed both to furniſh *ale* and *ſpirits*, and as it was uſed both ways, it is obvious that from the third and fourth parts of the preceding Report, there reſult two diſtinct ſtatements of the value of *raw Grain malted.*

In brewing ale the value can be eſtimated only from the proportion of *extract* contained in the wort. But the ſame method is practicable alſo in brewing for Diſtillation. Hence in *Diſtilling* there were two methods of aſcertaining the value of raw Grain malted. 1. By the proportion of *extract* yielded to water during the infuſion of the Malt. 2. By the quantity of *alcohol* or *ſpirits* produced.

The following Table exhibits the relative values of each kind of Grain eſtimated from the proportion of extract yielded in the Brewing, and in the Diſtilling Experiments, together with the mean of both, ſuppoſing, for the reaſons already ſtated, that the Engliſh Grain has the conſtant value of 100.*

	Value from Extract.		Mean.
	Brewing.	Diſtilling.	
Engliſh Barley - - -	100.	100.	100.
Scotch Barley - - -	97. 8	97. 8	97. 8
Scotch Bigg - - - -	88. 8	88. 0	88. 4

The very great coincidence between theſe two columns is not a little remarkable, and affords a ſatisfactory evidence of the care with which the Experiments were conducted.

The following Table exhibits the relative values of each kind of Grain, eſtimated by the proportion of alcohol yielded by the ſame bulk of each converted into Malt, ſuppoſing, as uſual, the Engliſh Grain of the conſtant value of 100.†

	Value.
Engliſh Barley - - -	100.
Scotch Barley - - -	90.
Bigg - - - - -	82.

Thus we have unexpectedly obtained two values of the raw Grain malted, differing from each other about 7 per cent. According to the firſt eſtimate, Scotch Barley is 2 per cent. and Bigg 11 per cent. worſe than Engliſh Barley; according to the ſecond, the former Grain is 10 per cent. and the latter 18 per cent. inferior to Engliſh Barley.

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* See Appendix, Number II.

† See Appendix, Number III.

3. Concluſion, by Dr. Thomſon.

Hence it follows, provided our Experiments are entitled to confidence, that the ſame weight of extract in the different kinds of Grain does not yield the ſame quantity of ſpirits. There is a ſuperiority of 7 per cent. in favour of the extract of Engliſh Malt. Thus an opinion which has long prevailed in Scotland has been unexpectedly confirmed.

From the preceding ſtatement it appears that Bigg in the ſtate of raw Grain, if we meaſure its value by the quantity of ſpirits which it is capable of yielding, is ſuperior to Engliſh Barley, but when we convert it into Malt it becomes 18 per cent. worſe. Thus there does not ſeem to be any coincidence between the value of the raw Grain, and of the ſame Grain when malted. The difference between theſe two values will be ſeen more diſtinctly from the following Table. It conſiſts of two compartments, each of which is divided into two columns. In the firſt compartment is exhibited the quantity of alcohol in pounds avoirdupois yielded by a buſhel of Grain while raw and when malted: in the ſecond, the value of the ſame is ſtated in per cents.*

	Alcohol per Buſhel.		Value per Cent.	
	Raw Grain.	Dº Malted.	Raw Grain.	Dº Malted.
Engliſh Barley - - -	9.0875	11.340	100	124.8
Scotch Barley - - -	9.7817	10.198	100	104.2
Bigg - - - - - -	9.8155	9.290	100	94.5

From this Table we learn that the Engliſh Barley, in our Experiments, increaſed in value by being malted no leſs than 25 per cent.; while, on the other hand, Bigg diminiſhed in value by malting about 5½ per cent.

With reſpect to the cauſe of this very unexpected change in the value of the different kinds of Grain by malting them; whether it was owing to ſomething peculiar to the Grain, or was occaſioned by the way in which the Experiments were managed, I am not in poſſeſſion of ſuch facts as can enable me to ſpeak with preciſion. Not being aware of it till all the maltings were concluded, it was impoſſible to make the requiſite obſervations.

It has long been a received opinion in this Country that Engliſh Grain malts better than Scotch. This opinion is confirmed by the reſult of the Experiments as ſtated in the preceding Table. Were a conjecture to be hazarded reſpecting the ſtriking inferiority of Bigg when malted compared with Engliſh Barley, it might be aſcribed to the diminutive ſize of the former ſpecies of Grain compared with that of the latter. Bigg being uſually ſown in the moſt unfavourable parts of the Country, while Barley is treated with every indulgence, the difference between the ſize of their ſeeds has become very conſiderable. Now any miſtake in the proceſs of malting, as giving the Grain too much of the *ſteep*, or of the *floor*, muſt affect ſmall Grain more than large. And as in malting there are many circumſtances which cannot be regulated at pleaſure; Bigg ought to ſuffer from theſe more than Barley, and therefore to make worſe Malt. It is very probable too, that leſs juſtice was done to the Bigg malted for the preceding Experiments than to the other ſpecies of Grain. Our Maltſters had been accuſtomed to malt Barley both the growth of England and Scotland, but were almoſt ſtrangers to Bigg, and gave it probably too much both of the ſteep and of the floor.

But let the cauſe of this inferiority in malted Bigg be what it may, unleſs we ſuppoſe it owing to accident in our particular trials, it deſerves the cloſeſt attention. Had the two ſpecies been of the ſame value while in the ſtate of raw Grain, the difference between them when malted would have been nearly a third. Now ſurely the ſuppoſition, that in ordinary years, Engliſh Barley is at leaſt equal to Scotch Bigg, is far within the limits of truth.

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* See Appendix, Number IV.

III.

VALUE OF THE MALT.

3.
Concluſion,
by Dr. Thomſon.

The third mode of eſtimating the values of the different kinds of Grain, is by contraſting the produce of *equal bulks* of Malt without any regard to that of the raw Grain from which it was produced.

Here, as in the former caſe, we have two diſtinct values; namely, 1. from the proportion of extract which each ſpecies of Malt yielded to water; and, 2. from the alcohol obtained by Diſtillation.

The following Table exhibits the relative values of the different kinds of Malt, eſtimated from the proportion of extract yielded both in Brewing and in Diſtilling, ſuppoſing the conſtant value of the Engliſh Malt 100. *

	Value from Extract.		Mean.
	In Brewing.	In Diſtilling.	
Engliſh Barley - - -	100.	100.	100
Scotch Barley - - -	102. 66	101. 68	102
Bigg - - - - - -	95. 82	96. 97	96.

The following Table exhibits the relative value of each kind of Malt, eſtimated by the quantity of alcohol yielded by equal bulks of each, ſuppoſing the conſtant value of the Engliſh Malt 100.

	Value from Alcohol.
Engliſh Barley - - -	100.
Scotch Barley - - -	96.
Bigg - - - - - -	90.

The ſame difference exiſts between the values of the Malt eſtimated from the *extract* and the *alcohol* yielded by each, as was obſerved in the raw Grain malted: the value of Scotch Barley and Bigg, as eſtimated from the *extract*, ſinking almoſt 7 per cent. when meaſured by the *alcohol*. This muſt be aſcribed to the ſame cauſe in both caſes.

If we now compare together the values of the *raw Grain* and of the Malt, no coincidence will be found between them, the different ſpecies of Grain approaching much nearer to equality in the latter caſe than in the former. This ſeeming anomaly is eaſily explained. It depends upon the *unequal bulks* of Malt yielded by the *ſame bulk* of raw Grain in the different ſpecies. The following Table exhibits the average number of buſhels of Malt obtained from 100 buſhels of raw Grain in our maltings.

	Buſhels of Raw Grain.	Buſhels of Malt.
Engliſh Barley - - -	100.	105 ½
Scotch Barley - - -	100.	99 ⅓
Bigg - - - - - -	100.	99.

This Table ſhews, that a buſhel of Engliſh Malt is the product of *leſs* than a buſhel of raw Grain, while the Malt of Scotch Barley and Bigg is produced from *more* than its own bulk of raw Grain †.

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* See App. Nº V.

† The Table in the text gives the average of the whole maltings. The particular maltings uſed in the Brewing and Diſtilling Experiments do not coincide with it exactly, nor indeed with each other. Hence the want of exact coincidence between the *Brewing* and *Diſtilling* Experiments, in the quantity of extract furniſhed by the reſpective Malts. The following Table exhibits the number of buſhels of the Malt uſed for Diſtillation, which were obtained from 100 buſhels of raw Grain.

	Buſhels of Raw Grain.	Buſhels of Malt.
Engliſh Barley - - -	100.	105. 7
Scotch Barley - - -	100.	101. 5
Bigg - - - - - -	100.	95. 9

3.
Concluſion,
by Dr. Thomſon.

IV.

COMPARISON OF THE VALUES.

Thus we have obtained no leſs than five different values of the Grain under examination. The following table exhibits the whole of theſe in one view.

	I.	II.		III.	
	Raw Grain.	Raw Grain malted.		Malt.	
		From Extract.	From Alcohol.	From Extract.	From Alcohol.
Engliſh Barley - - -	100.	100	100	100	100
Scotch Barley - - -	107.	97.8	90	102	96
Bigg - - - - - - -	108.	88.4	82	96	90.
	1.	2.	3.	4.	5.

Theſe columns not only vary from each other, but, between their extremes, there is an interval of little leſs than 30 per cent. It remains now to conſider, which of them will furniſh the neareſt eſtimate of the relative values of the Grain under examination.

1. The firſt column, *exhibiting the values of the raw Grain*, though of great general importance, cannot be employed in the preſent caſe, becauſe the object in view is the *value of Malt*, not of raw Grain. It muſt therefore be ſet aſide.

2. The Brewing and Diſtilling Experiments have furniſhed two diſtinct ſets of values, differing from each other about 7 per cent. Shall we conclude from this, that the Malt of Scotch Barley and Bigg is 7 per cent. better when uſed for brewing ale than when employed to produce ſpirits?

The method of operating practiſed by the Brewers, and the inſtruments which they employ, concur to ſhew that it is their uniform opinion, that the ſtrength of ale is proportional to the quantity of extract contained in the wort. This is the opinion by which the preceding Experiments on Brewing were regulated. But as nobody has been able to demonſtrate the *truth* of this opinion, as plauſible objections may be ſtarted againſt it, and as the preceding trials ſhew that the value of extract when uſed in Diſtillation is different in different ſpecies of Grain, it would, I think, be *unfair*, in the preſent ſtate of the queſtion, to conſider the *weight* of extract yielded by Malt as a true repreſentative of its value. The *ſecond* and *fourth* columns of the preceding Table ought therefore to be ſet aſide.

3. There remain only the *third* and *fifth* columns, which exhibit the value deduced from the proportion of ſpirits furniſhed by the different ſpecies of Grain malted. But theſe columns give us two ſets of values, differing from each other about 7 per cent; and doubts may be entertained which of them ſhould be adopted.

4. The firſt of theſe columns, or that which is founded on the compariſon of *equal bulks of raw Grain malted* and ſubjected to Diſtillation, obviouſly determines the kind of Grain which the Diſtiller ought to prefer for malting. As Bigg, by being malted, becomes 18 per cent. and Scotch Barley 10 per cent. worſe than Engliſh Barley, it is obvious that no perſon would malt the former ſpecies of Grain, while he could obtain the latter upon equal terms; and that if an equal rate of Duty were to be impoſed upon all, it would be nearly equivalent to a prohibition of malting the inferior Grain. Therefore, in determining the relative values of the Grain under conſideration, as far as theſe values are connected with the Duty levied upon them when malted, it is clear that the value of the *raw Grain malted* cannot be left out of view. It does not, however, furniſh us

us with a fair criterion for determining the value of the different ſpecies of Malt. It leaves out of view a fact of the firſt importance; namely, that a given bulk of Engliſh Barley *yields more* Malt than the ſame bulk of Scotch Barley or Bigg. Therefore, if we were to be ſatisfied with the third column of the preceding Table, we would ſink the value of the Malt of Scotch Barley and Bigg too low, while we raiſed that of Engliſh Malt too high.

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5. The laſt column of the preceding Table, which gives us the relative values of the *ſame bulk of Malt* when ſubjected to Diſtillation, will appear at firſt ſight to furniſh a direct anſwer to the queſtion which occaſioned the whole inveſtigation. And if the Duty were levied by the *real bulk* of the Malt, there could be no heſitation in adopting it. But this is not the caſe. The Duty on Malt is always levied by *calculation*; on the ſuppoſition that the bulk of the Malt is ⅕th leſs than the *greateſt* bulk which the raw Grain attained either in the *ſteep* or in the *couch.* From the Experiments detailed in the ſecond part of the preceding Report, it appears that the quantity of Malt really produced ſometimes falls ſhort of this *ſuppoſed quantity* for which Duty is charged, but that more commonly it exceeds it a little. It appears alſo that Engliſh Barley yields a greater proportion of Malt not charged with Duty, than Scotch Barley or Bigg. Hence Engliſh Barley malted has an advantage over Scotch Barley and Bigg, which is not taken into account in the fifth column of the preceding Table. Were we to abide by that column, we would ſink the value of Engliſh Malt too low, and raiſe that of Scotch Malt too high.

6. Thus all the columns of the preceding Table of values have been examined, and none of them have been found capable of affording a preciſe anſwer to the queſtion propoſed. The firſt column is not applicable; we are not certain that the 2d and 4th columns do not exhibit deceitful values; the third column ſinks the value of Scotch Malt too low, while the fifth raiſes it too high.

7. But though the third and fifth columns are erroneous, the errors lie upon contrary ſides. Hence if we add them together, and take the *mean* of both, theſe errors will, in ſome meaſure deſtroy each other, and we ſhall obtain a new value, which probably approaches pretty near the truth. This is done in the following Table:

	Raw Grain Malted,	Malt.	Mean.
Engliſh Barley - - -	100.	100.	100
Scotch Barley - - -	90	96	93
Bigg - - - - - -	82	90	86

The laſt column of this Table I conſider as furniſhing pretty nearly the relative values of Malt from Engliſh Barley, Scotch Barley, and Bigg. If there be an error, the value of Bigg Malt is rated *too low.*

Thus it appears from the whole of this long inveſtigation, that the Malt of Scotch Barley is 7 per cent. and that of Bigg 14 per cent. inferior to that of Engliſh Barley.

But theſe values apply only to the crop of 1804, in which the Grain of the two Countries probably deviated not a little from the common ſtandard. There cannot be a doubt, that the inferiority of Scotch Barley and Bigg in common years is greater than we found it, though it would be hazardous to venture upon gueſſing at the exact amount. From what we have ſeen, however, there is reaſon to believe, that Bigg of very inferior weight falls off greatly in value, and may not perhaps yield more than has been alledged. But it may be queſtioned how far ſuch inferior Grain ought ever to be malted, or how far it would be proper to encourage the malting of it.

In the preceding review of the whole Experiments, the different qualities of Grain examined have not been contraſted; becauſe ſuch a contraſt, all circumſtances

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ſtances conſidered, would have been calculated only to miſlead. Almoſt all the ſamples of Bigg uſed in the *Diſtillery* Experiments, were in reality entitled to the name of firſt qualities, and the ſame remark applies with equal juſtice to the different parcels of Scotch Barley. This deficiency of inferior qualities in the Scotch Grain, is not to be aſcribed to any careleſsneſs on the part of the perſons employed to procure it, but to the uncommon goodneſs of the ſeaſon, in conſequence of which no very inferior Scotch Grain was to be found.

THOMAS THOMSON.

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APPENDIX.

TO facilitate the compariſon of the preceding ſtatement with the Concluſion which has been attached to the Report, I ſhall, in this Appendix, inſert the Tables from which the values which I have employed were deduced, whenever theſe Tables do not occur in the body of the Report itſelf.

I. Referred to from page 110.

TABLE: Shewing the quantity of alcohol produced from a mixture of raw Grain and Malt, and from pure Malt, from which the value of raw Grain is deduced.

	Alcohol in Pounds Avoirdupois.				D° per Cent. from raw Grain.
	From 40 Buſhels raw Grain and 20 Malt.	From 20 Buſhels Malt.	From 40 Buſhels raw Grain.	From 1 Buſhel raw Grain.	
Engliſh Barley - - -	579.288	215.786	363.502	9.0875	100.
Scotch Barley - - -	591.882	200.612	391.270	9.7817	107
Bigg - - - - - -	586.382	193.760	392.622	9.8155	108

II. Referred to from page 111.

The following Table exhibits the quantity of extract in lbs. avoirdupois, yielded by a buſhel of the ſame kind of *raw Grain malted*, both in the Diſtillation and Brewing Experiments, with the proportion per cent.

	Extract in Pounds.		Extract per Cent.	
	Brewing.	Diſtillery.	Brewing.	Diſtillery.
Engliſh Barley - - -	23.545	25.92	100.	110.1
Scotch Barley - - -	23.026	25.36	100.	110.1
Bigg - - - - - -	20.914	22.80	100.	108.8

From

From this Table it appears that $\frac{1}{10}$th more extract was obtained from the ſame ſpecies of *raw Grain malted* in the Brewings, for Diſtillation than in thoſe for Ale. This is to be aſcribed to the different way in which the two proceſſes were conducted. From the two laſt columns it appears, that in each ſpecies the difference kept very nearly the ſame proportion, and therefore gave very nearly the ſame relative values of the different ſpecies of raw Grain malted.

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III. Referred to from page 111.

The following Table exhibits the quantity of raw Grain in buſhels, from which the 60 buſhels of pure Malt employed in the Diſtillation Experiments were derived, the quantity of alcohol yielded by theſe 60 buſhels, and the quantity correſponding to a ſingle buſhel of raw Grain malted. The firſt column is added for the ſake of comparing this Table with that of the whole Diſtillations given in the preceding Report:

Number of Brewing.	Names of Grain.	Quality.	Buſhels of Malt uſed.	Buſhels of raw Grain from which the Malt was got.	Alcohol in lbs. from the whole Malt.	Alcohol in lbs. from 1 Buſhel raw Grain Malted.
71	Edinburgh & Linlithgow	1	60	56.23	598.32	10.640
72	Aberdeen Bigg - - -	1	60	63.76	594.12	9.318
73	Kent - - - - - - -	2	60	55.05	605.82	11.006
74	Linlithgow - - - -	2	60	58.37	594.04	10.178
77	Edinburgh - - - -	3	60	62.73	613.22	9.776
78	Suffolk and Kent - -	1	60	58.43	683.15	11.695
89	Eſſex - - - - - - -	3	60	56.82	643.15	11.320
90	Bigg - - - - - - -	2	60	61.37	568.45	9.263

From this Table we eaſily obtain the following, which exhibits the average quantity of alcohol in the avoirdupois yielded by a buſhel of each kind of raw Grain malted, with the correſponding value per cent.

	Alcohol per Buſhel.	Value per Cent.
Engliſh Barley - - -	11.340	100.
Scotch Barley - - -	10.198	90
Bigg - - - - - - -	9.290	82

IV. Referred to from page 112.

Were we to compare together the produce of pure Malt, and of the mixture of two parts of raw Grain and one part Malt, the difference, though leſs than in the Table exhibited in the text, would be ſtill very conſiderable. The following Table exhibits this compariſon, ſtated firſt in lbs. avoirdupois, and then in per cents.

	Alcohol per Buſhel.		Value per Cent.	
	Mixture.	Malt.	Mixture.	Malt.
Engliſh Barley - -	9.655	11.340	100	117
Scotch Barley - - -	9.865	10.198	100	103
Bigg - - - - - -	9.773	9.290	100	95

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V. Referred to from 113.

The following Table exhibits the quantity of extract yielded by a buſhel of Malt of each kind of Grain, both in the Diſtilling and Brewing Experiments, with the proportions per cent.

	Extract in Lbs.		Extract per cent.	
	Brewing.	Diſtillery.	Brewing.	Diſtillery.
Engliſh Barley - -	22.212	24.530	100	110.4
Scotch Barley - - -	22.803	24.942	100	109.4
Bigg - - - - - -	21.305	23.788	100	111.6

From this Table we ſee that the average difference between the extract yielded by the buſhel of Malt in the Brewing and Diſtilling Experiments was nearly $\frac{1}{10}$th, as in the caſe of *raw Grain malted.* But there is a little leſs coincidence between the proportions in the different ſpecies. This is owing to the quantity of Malt obtained from a given bulk of raw Grain not being the ſame in each.

THOMAS THOMSON.

4.
Letter to the Commiſſioners of Exciſe, Scotland, by Dr. Hope.

LETTER from Dr. HOPE to the Commiſſioners of Exciſe, *Scotland.*

Hon^ble^ Sirs,

AS Dr. Thomſon, in his *Concluſion,* has ſtated, that the Malt made from Bigg is 14 per cent inferior to that made from Barley, while Dr. Coventry and I have in our *Concluſion* reckoned the inferiority at 8 per cent. it may be acceptable to the Honourable Board to ſee, in a few words, whence ſo great a difference has proceeded.

The Board knows well, that in our inveſtigation two diſtinct Sets of Experiments have been carried on, one in the Brewery, another in the Diſtillery.

It is the practice of the moſt intelligent Brewers, to eſtimate the ſtrength and value of Malt for making Ale, by the quantity of *Extract* which it yields to water.

Dr. Thomſon, who drew up that part of the Report which relates to Brewing, has ſtrongly expreſſed the opinion we all entertained, that the quantity of Extract is a real meaſure of the value of Malt when applied to the purpoſe of Brewing.

In our Experiments, the Bigg Malt, in equal meaſures, afforded nearly 7 per cent. leſs extract than the Barley Malt.

When Malt is uſed for Diſtillation, the value is eſtimated by the quantity of Spirits which it yields. We found that the Bigg Malt produced about 9 per cent. leſs Spirit than the Barley Malt.

Thus for Brewing, the Bigg Malt proved 7 per cent. and for Diſtilling 9 per cent. worſe than the Barley Malt.

Dr. Coventry and I, in our Concluſion, took the average of theſe two reſults, and conſequently ſtate the quality of the Bigg Malt to be 8 per cent. inferior to that of the Barley Malt.

Dr. Thomſon, on the other hand, in his Concluſion, entirely rejects the reſults obtained in the Brewery Experiments, and retaining only thoſe got in the Diſtillery, which give the leſs favourable view of the value of the Bigg Malt, ſtates

ſtates that Bigg Malt, bulk for bulk, is between 9 and 10 per cent. inferior to Engliſh Barley; and ſo lowers, in ſome degree, the value of the Bigg Malt below our ſtatement.

4.
Letter to the Commiſſioners of Exciſe, Scotland, by Dr. Hope.

The reſt of the reduction Dr. Thomſon makes out in the following way:

When Bigg is converted into Malt, it produces a ſmaller bulk of Malt than the ſame meaſure of Engliſh Barley, and of courſe, if the produce of the Malt be eſtimated by the meaſure of the raw Grain, in place of the Malt, it will turn out ſtill leſs favourably for the Bigg Malt. Calculated in this manner, the proportion of Spirit yielded by Bigg Malt falls 18 per cent. ſhort of that yielded by Barley.

Dr. Thomſon adopts this mode of eſtimate, and ſtriking the average between the reſult which it gives, and the reſult got by eſtimating by equal meaſures of Malt, arrives at his general concluſion, that the value of Bigg Malt is 14 per cent. below that of Engliſh Barley Malt.

As the Duties on Malt are levied without any reference to the raw Grain, neither Dr. Coventry nor myſelf could admit of a reference to the raw Grain, in our eſtimate of the value of the Malt.

Hence Dr. Thomſon has depreſſed the value of the Bigg Malt below our ſtatement.

1ſt. By rejecting the reſults of the Brewing Experiments:

2d. By introducing a compariſon of the produce of Spirit by the meaſures of the raw Grain, in addition to that by the meaſures of Malt.

I am, Hon^{ble} Sirs,
Your moſt obedient Servant,
THO^{s} CHA^{s} HOPE.

Edinburgh, 30th April,
1806.